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Knowing the Ropes: The Need to Record Ropes and Rigging on Wreck-Sites and Some Techniques for Doing So

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Wreck-sites often produce large quantities of rope and rigging. For a number of reasons these are seldom systematically recorded or interpreted. It is argued here that the justifications produced for this are in many cases not tenable. However, one problem has been a lack of practical techniques, and insufficient training in how and what to record. This issue is discussed and some solutions offered. It is also argued that study of rigging could tell us much about the vessels, the processes of their wrecking, and the maritime world in which they operated.

Key words: rigging, rope, cordage, chafing-gear, recording.

Excavation is by definition a destructive technique. If we do excavate, it should be done with caution, and high standards should be paramount. One area which has been conspicuous by its frequent omission from archaeological wreck-excavation reports is rigging and its related items. It is often claimed that the actual rigging, as opposed to items in storage, does not survive in an intelligible form on wreck-sites. On the contrary, those of us who have excavated wreck-sites know that in many, if not most, cases, rope and its associated rigging elements are preserved in considerable quantity. It does not appear to last long in the water-column, so many well-preserved but unburied Baltic wrecks have little cordage. However on wrecks where leather, cloth and wood have been preserved, and 'hard' rigging elements such as blocks were buried early enough to be well preserved, cordage will almost certainly also have survived. Sadly, cordage is too often destroyed *in situ* without even being surveyed, and the hard rigging elements such as blocks are often displayed in museums out of context as an assorted heap of 'pretty' objects.

Examples of wrecks where cordage was present include *Mary Rose* (Rule, 1982: 140–48; Marsden, 2003: 83), *Vasa* (Cederlund, 2006: 368–9, 401–04, figs 12.13, 13.8–11, 14.11–12; Magnus, forthcoming), Red Bay (Bradley, 2007: 27–8), *La Belle* (Corder, 2007), *Invincible* (Bingeman, 1985: 21), and the five French ships burned at La Hougue (personal knowledge). Even an exposed wreck like the *Kennemerland* produced some rope (Price and Muckelroy, 1974: 263; 1977: 214–6, figs 6, 35). It can be equally true of much earlier wrecks, and in places like the Mediterranean, where large amounts of organic material are commonly believed not to survive. Examples include several of the wrecks in Tantura lagoon and the Ma'agan Mikhael wreck, in Israel, the Port Vendres wreck (DRASSM, unpublished archives), and the Marsala wreck off Sicily. However, for wrecks from all periods the levels of recording, recovery, analysis and publication have varied greatly in detail, scope and quality. Four published examples may serve as illustrations.

Kahanov *et al.* (2004: 122) have a significant section on the 9th-century Tantura B wreck, excavated 1994–96, where they state that 'no rigging elements were identified', and, using published details of the excavated hull-structural details, hypothesize about the ship's rig. But then in Polzer (2008: 225) we have 'Rigging Elements Recovered from the Tantura B Shipwreck', describing 'numerous rope fragments'. This contradiction would appear to be in part the result of the degree of priority afforded during and after wreck excavations to publishing hull-structure. Unfortunately, having recognised the importance of accurately recording cordage and rigging, Polzer describes hawser-laid rope as 'cable', S-twist as 'right-handed', and fails to recognise marline hitching around what appears to be a form of selvagee strop (2008: 229). Cordage, matting and rigging elements have been found on several wrecks in the Dor/Tantura Bay area, suggesting it is conducive for the preservation of cordage, although little detail has been published, in contrast to the structural studies.

Beltrame and Gaddi describe in some detail a number of excavated 2nd-century-AD 'hard' rigging artefacts from the Grado wreck, but the only reference to associated cordage is that 'under the starboard side of the prow many pieces of ropes of various thickness were discovered' (2005: 83). Martin (1979) on *La Trinidad Valencera,* recorded 'hard' rigging, took measurements of associated cordage, and recorded the structure of a large 4-strand cable which was presumed to have been for the anchor. Recognising the importance of recording these remains, despite not properly understanding them, Colin Martin has generously suggested that the contents of this paper would have helped significantly back then. Those of us who excavated the *Mary Rose* were in much the same position. Had we possessed a better understanding of what we were looking at and known how to record it, those writing the full report might have had rather more to work with.

The Red Bay excavation report (Bradley, 2007) breaks new ground in the recording, analysis and reconstruction of a vessel's rig. However, while a considerable amount of standing-rigging rope was excavated and its position and relationship to a number of 'hard' rigging elements was recorded, the structure of the ropes themselves was not, nor is it clear whether all the fibres were analysed. It is also clear that the essentials of rope construction and manufacture were not clearly understood. Over the past 40 years, papers, reports and theses based on archaeological finds of rigging from wrecks, or with substantive archaeological cordage and rigging content, are few. The work over the last 20 years by Ole Magnus at Roskilde, although largely unpublished in English, includes a guide to recording for archaeologists, which has meant that in Scandinavia cordage is often better recorded than elsewhere. Volume 2 of the *Vasa* report, devoted to rigging, promises to be exceptional (Pipping and Hocker, forthcoming). Of shorter papers on the subject, arguably one of the best is by Henderson and Stanbury (1983) concerning the 19th-century wreck of the *James Matthews*. What is unusual is not that the rigging cordage survived, but that its excavators chose systematically to excavate, record, and publish it in a dedicated paper.

In the same way that ship-structure, tool-marks and environmental evidence were ignored in the 1960s, the technology which provided the motive power for the now-assiduously-studied hull-structures—the sails, masting and rigging—are today still largely ignored, particularly the 'soft' rigging elements—essentially cordage. Rigging, rope and cordage are not mentioned in either edition of *The NAS Guide to Principles and Practice* (Dean *et al.*, 1992; Bowens, 2008). Having decided that the excavation of cordage is impractical, the justification produced for not trying is often that we have more complete evidence from models, pictures and written works—an argument long-since abandoned with regard to hull-structure. In terms of comparison with environmental archaeology, the study of rigging and cordage today is at about the same stage as when the contents of amphoras were tipped out under water.

It should be said that there is a desire among archaeologists to improve the recording and understanding of rigging, but a perceived lack of understanding as to how to go about it. It seems extraordinary that this state of affairs has continued for so long. Rigging was not an add-on—it was a major part of the investment in a ship, requiring major industry to support it. A late-17th-century French 1st-rate naval vessel required 100 tons of cordage for rigging and stores; a French frigate of 1790 required 27 km of cordage for the rigging and a further 5 km for replacements (display panels, Musée de la Marine, Rochefort). A late-18th-century British 74-gun ship required *c.*80 tons of rope to rig it, and some 922 blocks (May, 1987: 40). The replica of James Cook's 98-ft-long *Endeavour* has more than 200 lines and over 550 blocks (personal experience).

Hull-structure was in part a product of rigging technology; the rig carried by a ship was in turn partly a product of the type of trade in which it was engaged; and this rig and the sails, not the hull, is what propelled the vessel. The other point which needs to be remembered is that shipwrecks are an abnormal data-set—vessels which, for whatever reason, did not make it to their destination. As archaeologists and historians, we should be looking forensically for evidence about the condition of the vessel, the capabilities of her crew, and the circumstances of her sinking. The state of the surviving rigging is one of these clues.

What follows has been developed from many years of practical experience and developing techniques on several wreck-sites, but particularly those of two adjacent wrecks on the Natière Reef in St Malo roads, *La Dauphine* (1704) and *L'Aimable Grenot* (1749). Examples from these are cited by way of illustration; the full excavation reports are still in progress.

Given the paucity of archaeological data, study of rigging and cordage has relied to a large degree on archival or iconographic sources, and models. A number of documents have been published or re-published, notably in the early-20th century by the Navy Records Society and the Society for Nautical Research. Ashley (1944) is still the definitive work on knots and aspects of rigging and cordage, but some of his assertions about usage and traditions need to be treated with caution. Some 25 years ago Ian Friel conducted and published some valuable archival research (1983; 1994), but there has been little subsequent systematic work on rigging archives. John Harland (1984) has approached the subject of historical rigging from a practical sailing perspective. Largely as a result of the excavation of the *Mary Rose* and the archival, archaeological and practical research it stimulated, we now know much more about Tudor guns. Replicas have been made and tested, and a multi-authored report is in preparation. In contrast, before the *Mary Rose* excavation we did not know precisely what the 'poleankers', 'stryks', 'trepgatelynes', 'tragetes', 'dryngs', or 'sherwynes' referred to in documentary sources were. Sadly, 25 years after she was raised, we still cannot identify these rigging components, and no systematic post-excavation research has been undertaken on the rigging.

The work of people who were primarily model-makers, such as Frank Howard (1979), James Lees (1984) and R. C. Anderson (1927), is good as far as it goes, but except for Howard their work was largely published before the advent of systematic underwater archaeology. Anderson's work is over 80 years old. These individuals have died, and there seems to be little interest in developing and updating their work. Yet this is necessary because reliable contemporary sources are limited. Artists were seldom riggers or shipwrights, so pictures are seldom accurate. Rigging may obscure the composition and is not always aesthetically pleasing, so is only selectively portrayed. Models seldom have their original rigging, and problems of scale mean that the detail of the real object cannot be replicated. A further limitation of rigging on models is that they are representational or instructional. They were not working vessels. For example, chafing-gear, which is the product of a combination of day-to-day experience aboard a working vessel, and the practical skills of her crew, is never shown on models.

As for contemporary sources, the classic texts such as Sutherland (1711) and Steel (1794), useful though they are, probably need to be treated with caution, as they were often compiled by non-specialists from other people's sources, rather than written by people who got their hands dirty. Others, for example du Monceau, are probably somewhere in-between. In Steel there is at times a lack of clarity, suggesting that he was repeating things he did not fully comprehend. As for contemporary first-hand archival sources, rigging inventories, bills, and account books, some were transcribed by Oppenheim (1896a; 1896b), unfortunately in an edited form; many are surely still to be discovered, but will not be unless people look for them.

This paper has four main aims: first, to explain why rigging has generally been poorly recorded; second, to persuade those who are still excavating that there are things which rigging can tell us; third, to offer some techniques to make excavation, initial conservation and recording a practical and effective proposition; and fourth, to set out some of the major unanswered questions relating to rigging and cordage traditions, and the associated rigging-supply trade. The hope is that the response will also be fourfold: constructive criticism and further suggestions as to how rigging can be better excavated and recorded; agreement on a standardised form of recording and terminology which will thus be internationally comparable; a marked increase in the study of ropes and rigging from wrecks; and the development of an internet group to exchange information, hopefully culminating in a form of online comparative database to aid the analysis of future finds.

The problem with excavating cordage

Just as our knowledge of ceramics enables the provenance of small sherds to be identified relatively quickly, it would seem likely that once we focus on rigging and cordage we will find we can analyse and provenance fibres, tar and other protective treatments, and associate these with knot-types and rigging conventions and traditions. Why, therefore, have woven and twisted materials—textiles, rope, basketry and withy work—so often been poorly recorded by archaeologists? Arguably the reasons are multiple but solvable. These items are usually fragile, tangled, difficult to excavate and difficult to record. Cordage is at once both banal and mysterious. The structure of woven and twisted materials is often unintelligible to non-specialists, but instinctively self-evident to those who are familiar with the techniques involved. Recording-methods and vocabulary are not standardised, and have tended to require specialist knowledge, involving either time-consuming drawing or complex notational systems. In some cases, because their academic inventor did not fully comprehend the method of construction, crucial information is lacking or not decipherable by subsequent researchers.

There should be no illusions as to the difficulty of excavating and recording rigging, tons of which winds up in an apparently indecipherable mess on the sea-bed after a shipwreck. Another problem is that significant parts of the rigging are likely to be located away from the main wreck-site. However, because many archaeologists do not understand ropes or rigging, they have not thought about what questions to ask of the remains they do find, and have not acquired the skills to record their finds in a way that is informative to specialists. But if we do not ask questions of a wreck's rigging, we can have no idea what answers it might yield. Having decided that excavating and recording rigging is impractical and of limited archaeological value, time and money is seldom allocated to investigate it. Cordage on a wreck is often seen as a rotten, smelly and tangled inconvenience, frequently overlying the artefacts and structure.

It seems reasonable to suggest that, as a minimum, all maritime archaeologists and nautical specialists need to be able to distinguish, at a glance, whether a piece of cordage is hawser or cable-laid, whether it has been served, whether worming is present, whether there is chafing-gear present, what types of knots are associated with it, and to be able quickly to recognise and record the relationship between the various elements. These specialists, who spend considerable time on boats, need to acquire a basic competence in knot-tying and maritime ropework.

The structure and principles of cordage

In order to understand the rest of this paper a simple experiment is necessary. Get some fibres—grass, hair, wool or a piece of string. Twist the fibres together until you have a length of about 30 cm. You have now spun a yarn. Hold the ends apart and, keeping the length under slight tension, continue to twist it. Keeping the twists in place, bring your hands together, easing the tension so the length begins to drop in a loop. The counter-twist which suddenly combines the two sides of the loop is called 'laying'. You have just laid cordage composed of two strands, each strand of which has one yarn. Now make several yarns, place them alongside each other, and repeat the procedure. You have now made a thicker cord, composed of two strands, made up of however many yarns you placed together and twisted. Note the difference between twisted (the ropemaker's term is 'spun' for yarns and 'formed' for strands) and laid. The latter locks the yarns together with a counter-twist, the former does not (Fig. 1). It is essential to understand this elementary concept of ropemaking in order to be able to develop workable systems for recording cordage finds.

Along with stone tools and fire, cordage is probably one of the most ancient technologies. It can be plaited, but the vast majority is twisted. The principle is that fibres or lengths of material, usually botanical in origin, are twisted to make strands which are a common feature of all ropes. Strands may be just one item (such as a stem of honeysuckle), or a large bundle of fibres. A refinement in ropemaking is the building of strands from numbers of yarns. Two or more (generally up to 4) strands are twisted simultaneously at one end, and allowed to untwist (that is, turn in the opposite direction) by twisting against each other at the other end, creating the completed laid cordage. This counter-twist has several functions: it locks the strands together, and, by creating a helix, balances out the distance that different parts of each strand has to travel along the rope, especially when it is bent (rather like staggering runners on an athletics track). This degree of twist affects both strength and flexibility.

The direction of the twist can be either 'S' or 'Z' (Fig. 1) (American Society for Testing Materials, 1952). The most usual convention is to twist in a 'Z' direction (when spinning by hand, left-handers tend to create yarns with an 'S' twist). The terms 'left', and 'right', are traditional ropemaker's terms for S and Z. 'Clockwise' and 'anticlockwise' should not be used, as the direction depends on the position of the observer, so creating confusion. The most important factor is consistency in the terms used. More sophisticated ropes may

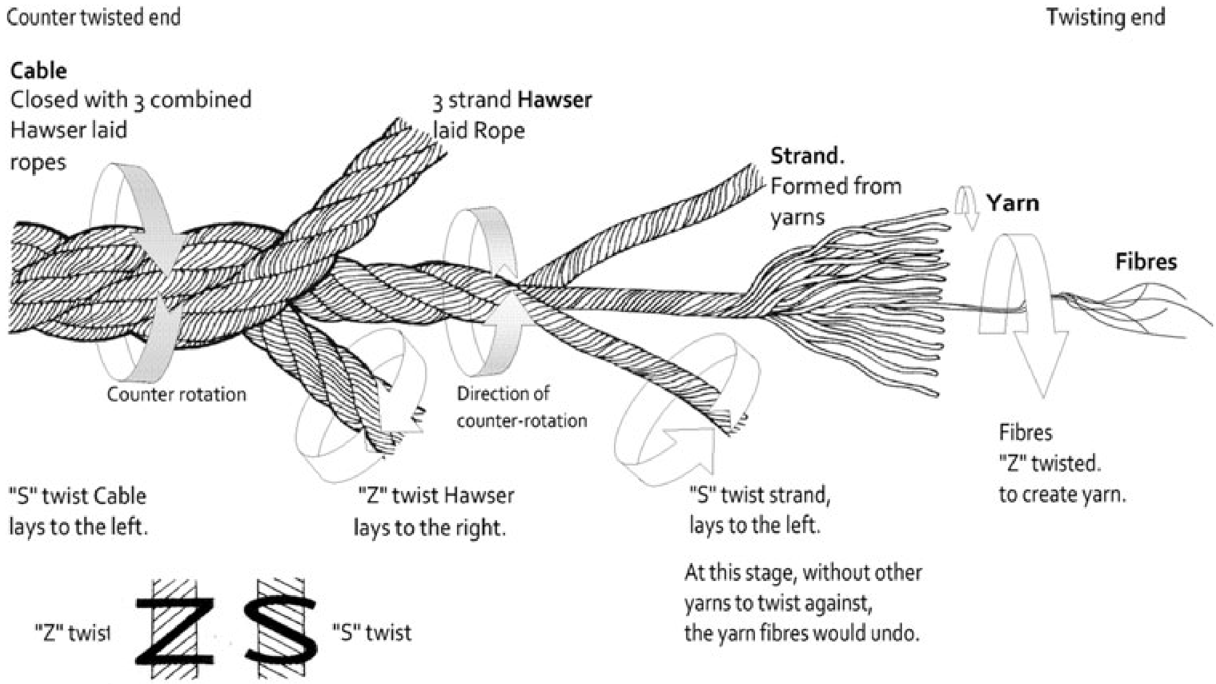


Figure 1. Illustration of generic post-medieval, machine-laid, cordage construction. (D. Sanders, after Tryckare, 1964: 140)

have their strands made up from a number of yarns, which are usually between 1.5 and 4 mm in diameter. The twisting or spinning of either the yarn or strand fibres binds them together and allows new lengths of fibre to be spun in, permitting the construction of long continuous yarns. Before being put into a strand, yarns may themselves be laid; particularly with hand-laid as opposed to machine-laid cordage. These yarns are then placed alongside each other in varying numbers to make strands. The number of yarns and the diameter of the yarns in a strand, and finally the number of strands, determine the size of the cordage. A modern exception is the manufacture of continuous synthetic polymer fibres, which do not need twisting, but which are held together by an outer sheath.

Rope terminology

Most of the terms used for ropemaking, at least in Britain and France, relate to conventions which developed in the late-medieval period and which were described in 17th- and 18th-century treatises. However, there has been slippage in the terminology over time, to the extent that if one takes the various terms in the European tradition and applies the definitions of each given by different historical treatises, modern ropemaking companies, dictionaries and archaeologists, not to mention people from different trades and nationalities, we appear to have stepped through the looking-glass, and, like Alice, run into Humpty Dumpty who insists that 'when *I* use a word, it means just what I choose it to mean, neither more nor less' (Carroll, 1897: 123). The end result is that it is difficult, if not impossible, to understand what is being described when referring to records from archaeological sites, let alone be able to compare and replicate the cordage—which should be our aim.

It is proposed that any terms used should be as historically appropriate as possible, unambiguous, distinct, and consistent, and that clear existing or historical terms should not be arbitrarily redefined. In an attempt to circumvent these problems, and to be able to incorporate all structural traditions, Dixon (1957: 135), following Osborne and Osborne (1954), developed a hierarchical system in which he substituted the terms 'Stage I' to 'Stage IV' cordage, for the names 'yarn', 'strand', 'rope' (hawser), and 'cable'. However, the numerical substitutions still need to be defined, just as chemical structures have both formulae and names. More fundamentally, Dixon, like the Osbornes, did not grasp that the spinning or twisting of fibres in yarns (Stage I) and the twisting or forming of yarns into strands (Stage

II) are fundamentally different to the structure of Stages III and IV (cables and hawsers), which are not simply twisted together, but rather their separate strands are first twisted ('formed'), and then placed together and allowed to untwist by counter-twisting around each other ('laid' or 'closed'). He also failed to appreciate that these neat 'stages' cannot incorporate the structural variety seen in some cordage, particularly ancient, hand-made and small-diameter types. As a result, his definitions of yarn, strand, hawser and cable were inaccurate, and as a practical description his hierarchy was confusing to the point of being unusable. This is a pity: firstly because a number of people have got into a mess trying to make it work; and secondly, the reasoning behind his argument had some merit. Although the terms 'formed', 'laid' and 'closed' are ropemaker's terms, they are not ideal for our purposes, as they have several other uses and meanings, creating potential for confusion. For now, however, they are the best we have.

Unfortunately however, others adopted as a solution the textile term 'plying' or 'plied' from Emery (1966: 10). Plied or compound yarns are yarns which have been counter-twisted or laid; in effect they are miniature rope. Examples of plied yarns are found in rope made without a ropewalk, notably some ancient Egyptian cordage, and one could argue that a yarn which is first spun and then plied, would be a valid use of the term, not least as it would appear to offer a simple way of reconciling ancient and post-medieval structural traditions. However, Schjølberg (1988: 76–7) and Wendrich (1991: 142, 144), and more recently Veldmeijer (2005), have used the terms 'plied', 'ply' or 'plying' to describe an inconsistent and incomprehensible mix of Z- and S-twist plied yarns, yarns which are unplied but formed in strands, and as a name for the rope strands themselves. Dixon (1957) advised against the use of the term 'ply' because of its vagueness.

The origin of this trend appears to be the work of Wendrich (1991), because in what was in many ways a ground-breaking book, her definitions of 'ply', 'string', 'strand' and 'cable' appear to have similar conceptual deficiences to Dixon's, while adding some of her own. A number of her definitions are confusing, idiosyncratic, inaccurate, and conflicting. She also presents her own definitions where artisanal terms already exist. She describes yarns as Z- or S- or untwisted fibres plied into a string which is plied into a strand which is cabled into a rope. Even more confusingly, she and Veldmeijer seem to define 'strand' as any long length of something, including finished rope, as well as its distinct ropemaking definition (which Veldmeijer also calls a 'ply'). They use the term 'cabling' for laying strands into a hawser, 'cable' for a hawser, and 'double cable' to describe what everyone else in the maritime world calls a 'cable'. Veldmeijer defines rope as cordage of a diameter greater than 10 mm, when the indisputable historic definition is cordage with a circumference greater than an inch (*c*.8 mm diameter), and defines string as cordage with a diameter of less than 10 mm, whereas Wendrich appears to use 'string' to describe plied yarn.

That this could occur some 20 years ago and continue unchallenged is perhaps an indication of how little attention has been paid to the subject. It needs to be resolved by further discussion, not least because several Mediterranean wreck-sites, including Tantura B (Polzer, 2008: 229), appear to be using these definitions, and Veldmeijer and Wendrich, working on terrestrial sites in Egypt, some of which contain boat-rigging, are among the few who are systematically recording cordage finds. While Wendrich and Veldmeijer's algebraic notational cordage-recording-system works at least for smaller items, it would seem wise to avoid their definitions completely.

For French and British post-medieval ship's cordage, it is proposed that we use the historical ropemaker's terms or their foreign-language equivalents, of yarns which are spun, strands which are formed, hawsers which are laid and cables which are closed (Fig. 1). 'String', and 'thread' are terms which should be avoided. They are imprecise, and each can include a variety of different constructions. It would seem logical that once the terms listed below are agreed, they should not be used in any other context. The original sources are not without their contradictions, one of the most confusing being Luce (1891: 21–30). Traditions in Europe at this time were broadly similar, and French definitions are included below. The following attempt at a British classification has been made using du Monceau (1769: chs 7–10), Steel (1794: 53–70), Lever (1818: 1–3), Stopford (1925: 1–4), Ashley (1993: 23–4), and Harland (1984: 232–3).

***Cord* (cordage)**

Singular noun (plural cordage). The generic term for animal or vegetable fibres, withies, sinew, leather, hair, moss and similar material kept together by twisting to provide cohesion, flexibility, dimension and length. Cordage can be knotted or joined.

***Small stuff* (petits cordages)**
A generic term for any cordage whose components have been laid (combined with a counter-twist) with a circumference of less than 1 inch (25 mm). It covers a variety of different constructions and names, which have an equally varied, and sometimes contradictory, set of historial definitions. Its precise structure and detail of use need to be recorded on an individual basis.

***Rope* (cordages)**
A generic term for any laid or closed cordage with a circumference greater than 1 inch (25 mm) or 8 mm diameter.

***Yarns* (fils de caret)**
Composed of spun fibres, that is the fibres are twisted to adhere by friction and the yarn elongated by progressively twisting in new lengths of fibre; usually Z-twisted (sometimes termed 'right-handed' or 'counter-' or 'anti-clockwise'). Fibres vary in thickness, the highest quality generally being the thinnest, and containing the least amount of non-fibrous stalk material known as 'hurds'.

***Strands* (torons)**
Are formed; usually S-twisted (sometimes termed 'left-handed' or 'clockwise'). All laid cordage is composed of two or more strands; not all strands are composed of multiple yarns. While the yarns have been twisted in a Z direction during spinning, in 'plain' or 'hawser-laid' rope each of the strands is twisted separately but simultaneously in an S direction. If this was done to a single yarn it would untwist its fibres, but when several yarns in a strand are twisted in this direction, they become twisted against each other before they can fall apart. The fibres, by being untwisted, are aligned more along the axis of the rope, making it more supple, and reducing shear-forces on the fibres, increasing its strength. There are variations to this system, used for ropes with special functions. In English 'strand' can also refer to a hawser closed with others to form a cable (*cordons*).

***Hawser* (aussière)**
A rope, usually of three strands laid together, usually in a Z-twist. Plain or 'hawser-laid' rope is rope which follows this convention. Pre-19th-century hawsers could probably not be made larger than about 9 inches (229 mm) in circumference, or 73 mm in diameter. By the 20th century the term 'hawser-laid' had come to be used only for large plain-laid ropes used for towing, warping and mooring. To add to the confusion, manufacturers began calling this 'shroud-laid' (see below).

***Cables* (grelins)**
Closed, usually S-twisted, a cable is a rope of 9 inches (229 mm) circumference or 73 mm diameter and upwards, consisting of at least three 3-strand hawsers which have been closed to become S-twist. Before the 19th century it was the only reliable means of making ropes larger than 9 inches in circumference. Cable-laid rope is usually made by closing (combining) three plain or hawser-laid ropes together in an S-twist. Stays were sometimes made from 4-strand or 4-hawser cable. Because the hawsers had to be tightly Z-twisted in order to impart the final S-twist in the cable, cables were believed to have several useful qualities: that their structure made them less liable to failure from chafing; that they were relatively impervious to water, being known as 'water-laid'; and that the extra twisting possibly gave them a greater degree of elasticity. However, because the fibres were more twisted, lying at a greater angle to the axis of the rope, they were weaker under tension due to greater shear forces acting on the fibres.

Cablet
Cable-laid ropes, less than 9 inches (229 mm) in circumference.

***Core* (mèche)**
Sometimes known as the heart (*âme* or soul) and historically as a 'goke', this is a central fill of yarns, or occasionally rope or small stuff, used to fill the void created when a rope is made of more than 3 strands. With steel-wire rope this core has the additional role of being impregnated with oil to inhibit rusting and to lubricate the movement of the wire threads.

Shroud-laid
Z-twist, 4-strand hawser with a core, used for shrouds and other standing rigging before the advent of wire rope. Shroud-laid rope is also known as 4-strand rope, or 4-strand hawser; when laid for general uses it is more flexible than

3-stranded, and sometimes used for boat-falls, bucket-bails and lanyards.

Backhanded or reverse-laid
Sometimes erroneously called 'left-hand rope', this consists of conventional Z-twist yarns which have been further Z-twisted in strands to produce an S-twist rope. The heavily-twisted yarns are weaker as a result, but, perhaps because the twisting separates the yarns from each other in the strand, the rope is said to be more flexible, and less prone to tangle or kink. It was often made 4-stranded because this reduced the amount of twist in the yarns. Its disadvantages are its weakness, absorbency and lower resistance to wear. Rope folklore (which requires archaeological confirmation) claims it was used as braces, gun-tackle falls (4-strand), and hammock lanyards. Apparently (according to a former National Serviceman) up to the 1950s its use for hammocks was a question in a Royal Naval exam.

Left-hand or left-laid rope
This is the exact opposite of plain-laid rope, and begins with specially-made S-twist yarns. Folklore says it was used in seine nets with plain-laid rope, the twist of one compensating for the twist of the other. This does not appear to be borne out by examining such nets, although backhanded rope is found. On HMS *Victory* the gun breeching-ropes and some others have been reconstructed from left-laid rope. The validity of this will be discussed later.

Spun yarn
A confusing name for a class of small stuff made by laying from 3 to 8 yarns, S-twist and long-laid. It is used for lashings, seizing and serving. *Merlin* (French), used as spun yarn, but only 3-yarn, 3-strand, and tighter laid, S-twist. *Bitord* (French), 2-yarn, 2-strand, S-twist.

Twine
A seaming 'thread' used at sea and in sailmaking. It is made of two single yarns loosely twisted. Unfortunately some 3-yarn seaming 'thread' is also called twine, and in general speech it has become synonymous with string.

Nettles
Two or 3 Z-twist yarns which are re-twisted to form S-twist yarns and then laid up as Z-twist small stuff. Probably made on board from old rope.

Foxes
Short left-hand S-twist cordage, constructed from Z-twist yarns. Probably made on board from old rope.

Long-laid, short-laid
This refers to how tightly the strands in a rope are laid, giving a rope its helical form. Short-laid rope is made from tightly-twisted strands, giving a tightly-laid rope. The groove created between the laid strands is sometimes known as the *jaw,* but more correctly as *cantlines, contlines,* or *cuntlines*. 'Long-jawed', or 'long in the jaw', was an English seamans' term for a an old, overstretched rope.

Lengths of rope-types
In practice this depended on the size of the rope-walk and how tightly the rope was laid. Stopford (1925) gives the length of a hawser as 113 fathoms (678 ft, 206.65 m), and of a standard cable as 101 fathoms (606 ft, 184.8 m). Other sources range from 85 to 120 fathoms. The 'cable' as a unit of distance measurement was 100 fathoms (183 m) in the UK and *un encablure* in France was 120 *brasses* (194.9 m). The rope-houses of the English Royal Dockyards were: Devonport 1200 ft (365.5 m), Portsmouth 1030 ft (313.7 m) and Chatham 1140 ft (347.2 m) (pers. comm. M. Read, University of Plymouth).

Ropemaking traditions

Ropemaking may be very ancient, but I am not aware that anyone has developed a full typology of the evolution of rope-construction from different traditions from the earliest times, for example in Asia. It would be valuable to have information about local variations in techniques and definitions, from shipwrecks or other first-hand sources. Considerable work has been done on ancient Egyptian cordage, but there are arguably gaps in analysis, and problems with the recording-system and definitions. Ole Magnus has compiled a history of Scandinavian ropemaking from the Neolithic to the present, based on archaeological finds (as yet unpublished). This is an area which needs further discussion, to agree on a standardised glossary of terms and a recording-system or systems which are compatible, and can cope with different structural traditions. Arguably neither exists at present, although most of the elements are there. Many of the terms defined above are applicable to cordage from any period. Once this is established, the focus can shift to the acquisi-

Figure 2. Paunch-matting (NAT 2235) from *La Dauphine*. (ADRAMAR, D. Sanders)

Figure 3. Des Pawson's modern version of paunch-matting. (D. Sanders)

tion of more well-recorded archaeological cordage, as well as the study and re-appraisal of existing collections. Analysis of ropes in this manner could reveal information about raw-material sources and preparation, production technologies, degrees of standardisation, construction traditions, their evolution and use, and possibly indicate cultural links.

Chafing-gear (*matelotage*)

There is one major aspect of rigging which is never shown on models, seldom in paintings, and only given cursory description in treatises. Sails and rigging rubbed and caused wear, and this had to be minimised. The items used were collectively termed 'chafing-gear', and were applied on the basis of experience on a particular vessel, and according to the knowledge, traditions and abilities of the crew. Sailing ships with their rigging wrapped with various forms of sennit; with sword- and paunch-matting (Figs 2 and 3), which were often threaded with teased-out rope yarns known as 'thrumming' or 'baggywrinkle'; with fenders and pads known as 'pudding', would have had a furry appearance (indeed the French word for serving is *fourrure*, 'furry') and not at all elegant. Recently, at least, there was a tradition of removing much of this on return to one's home port, in order to make the vessel look smart. Replacing it was part of routine maintenance, used to occupy the crew. Often it was made from unpicked strands and yarns of old rope. Not surprisingly, therefore, I am aware of only one artist

Figure 4. Area J23 (Natière 1, *La Dauphine*) in the early stages of excavation. (ADRAMAR, T. Seguin)

who has shown chafing-gear: Peter Breughel the elder, on a mid-16th century Flemish warship (Howard, 1987: 49, fig. 62).

Archaeological wreck-sites are the only potential source of information about where chafing-gear was used, what traditions there were, when they originated, and how they evolved. Experience of chafing on replica vessels might be instructive, and give some insight as to historical practical and economic considerations. My personal experience is that there is considerably less chafing-gear on replicas than found on the wreck of *La Dauphine*, for example. The *Endeavour* replica uses sword-matting to protect the masts and yards, *La Dauphine* used paunch-matting, which because of its 'knitted' structure, may be more resistant to wear than sword-matting. However there are difficulties with making comparisons. Many of these replica vessels are only sailed for short periods, and lack the numbers of suitably-skilled personnel to make large amounts of chafing-gear. Secondly, most if not all of them use materials other than hemp (*Cannabis sativa*), which is expensive and a controlled substance. Instead manila (*Musa textilis*), flax (*Linum usitatissimum*) made to look like hemp, and polypropylene synthetic hemp are most frequently used. These materials behave differently to hemp, and the quality of some 'traditional' rope used on replicas can be problematic. Indeed the *Batavia* replica was apparently originally rigged in 'hemp' (although this was probably flax), but this was soon replaced with other materials because it rotted (www.bataviawerf.nl/download/englishguide.doc; pers. comm. O. Pipping). In addition, one function of chafing-gear was to protect against water-penetration. In the modern, heavily-regulated 'disposable' world, rigging on replicas is perhaps viewed as far more disposable than on the original vessels, where ropes had a multiple life-cycle, being re-used in other capacities as they aged.

Blocks and other hard rigging elements

These include cleats, toggles, belay-pins, trucks and parrels, deadeyes, hearts and thimbles, fair-leads and blocks. Blocks can tell us a lot about their function and the rope which was used in them, even in the absence of the ropes themselves. The form of the block can give clues as to its age, the size of the rope it was stropped with, and how it was stropped. It is important to conserve the strop, as this can be diagnostic of the particular use for what might be a fairly standard block with several potential uses. Archaeological block finds often contain rope fragments. Care should be taken to recover and record these. Even a very short fragment can tell much about the rope, and is proof that the block was in use. In the absence of rope, the sheave can give a close approximation of the size of the fall (rope) running through it. Some blocks can give a rough indication of the size of the ship. As on the Natière wrecks (Fig. 4) the iron associated with the standing rigging to the masts is often found on and around the wreck in large unidentifiable concretions which may also contain other items. Digital radiography is a valuable analytical tool, helping guide resin-casting of concretions. However, large concretions still present a problem.

Rigging and site-formation processes

Oddly, even vestiges of masts seldom seem to survive in the marine environment. Exactly why is unclear. Perhaps some fall well outboard of the wreck, and are never excavated. A number of Baltic wrecks, and wrecks in lakes, have preserved masts, including *Vasa.* This might suggest that once the restraining rigging has parted, the extra buoyancy of salt water allows them to float away, and those elements that do not are vulnerable to being eaten by *Teredo navalis* (absent from the Baltic and lakes), or simply rotting because they are usually made from softwood. It should not be assumed that their absence is due to salvage. What rigging has been preserved, and its position in the wreck, can give clues to the wrecking itself and subsequent site-formation processes. The aspects which can be included in this category are weather, current, sailing manoeuvres prior to wrecking, condition of the rigging, quality, repairs, presence of fighting shrouds or shot damage, possible attempts to cut down masts, jury rigging, trying to warp off with anchors, post-wrecking salvage, and the position of rigging elements as clues to the collapse of the vessel's structure.

The Natière 1 wreck was not identified as *La Dauphine* until 2007. Part of the evidence confirming her identity came from her rigging. Lying alongside and partly under the hull was a large mass of rigging nearly 0.5 m deep, and several metres long, consisting of parts of the stays, shrouds, chafing-gear (Fig. 5) and associated blocks. Various concretions in the area appeared to be metal elements of the standing rigging. The standing rigging led under the hull, and a topgallant yard was found nearby, indicating that the vessel had sunk on top of one of her topmasts, presumably in calm weather. An entry in the St Malo log of corsair activities included a report of the wreck of *La Dauphine*, a vessel from Le Havre, on the Ouvras and Biron reef while entering St Malo on 11 December 1704 under the direction of a pilot:

> Sur laquelle ayant touché ou la ditte fregatte Sarresta tout dun coup quoy quen mesme temps le declarant Eust fait Jetter a la mer pour Salleger ses Canons Et couper les mats & fait tout ce quil Estoit possible pour Eviter le naufrage Mais laditte fregatte a Incontinan remply deau et Coullée (on which the frigate touched and stopped suddenly, and at the same time we jettisoned guns and cut the masts to lighten the ship and did all we could to avoid being wrecked but all the same the frigate filled with water and sank) (Archives Municipales, St Malo, AD35/9B/613–6 ff.78v–80).

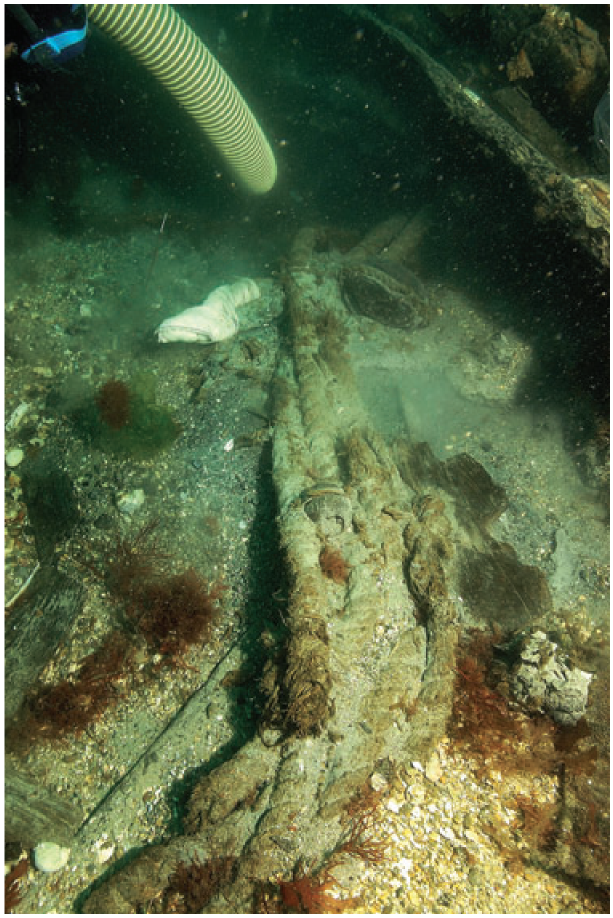


Figure 5. F 90 (Natière 1, *La Dauphine*) during excavation. (ADRAMAR, T. Seguin)

The Red Bay wreck is perhaps one of the first where a systematic plotting and analysis of the rigging remains has shed light not only on the rig itself, but on the wrecking process and post-wrecking salvage (Bradley, 2007: 27–8). In the case of the *Mary Rose*, we will never find the foremast because the Venetian salvors broke it, and the Deanes recovered what remained of the mainmast. Nor will we find any of the yards or sails which were rigged at the time of the sinking, because the Venetian divers in 1545 recovered them. Analysis of what was found where and what was missing would nonetheless be potentially instructive. The condition and alignment of the forward hull-remains, for example, may well be explained by the mechanics of breaking the mast while attempting to put the ship on an even keel during the salvage operation. The position of the shrouds which were found may indicate how the would-be salvors went about it, or what they did subsequently. Some initial speculations have been made (Marsden, 2003: 83) and the forthcoming hull report will hopefully have more detail.

A vessel which sank in a storm, or which had its top-hamper cut down, or salvaged post-wrecking, would have a completely different rigging profile as a wreck-site. It is worth reiterating that the *Mary Rose* was not powered by an engine. Whatever other factors may have been involved, she would almost certainly not have sunk had she been stationary and with no sails set. A significant factor in her sinking was the practicality of sailing a ship-of-war in a confined area in a current. Almost all disasters are the result of a confluence of mishaps which ultimately become irrecoverable. It is very seldom that a disaster occurs because of one overriding and irrecoverable event. The *Mary Rose* was no exception. The 1536 refit, heavier guns, extra soldiers crowded on decks, open gunports, possible damage from enemy fire, and 16th-century gunnery practices, all played their part, but were all bought into play as a result of sail-handling and manoeuvring the ship, which may have been difficult given the overcrowding. The anchor and cable found laid out on the upper deck may well be a significant element in this story, but the excavation records have never been examined in sufficient depth to make sense of this find fully, and omissions in excavation and post-recovery recording may prevent this.

Rigging-types and trade

Whereas the hull of a vessel, and certainly its lines, would probably remain largely unaltered during its lifetime, the same could not be said of its rig. Rigs were changed to suit particular requirements and voyages throughout a vessel's life. This is, however, a subject which is poorly studied and incompletely understood. This is relevant as a diagnostic tool on wreck-sites, and, where the identity of a wreck is known, archaeological analysis of its rig can help improve our understanding of the evolution of different rig-types and the trades in which they were used. Square-rigged sails are more secure and effective in running before the wind, particularly in storms or on the high seas. Fore-and-aft sails are cut to provide the maximum aerodynamic effect from the air passing over them, and they enable a vessel to sail closer to the wind than square sails, thus giving more manoeuvrability. Most fore-and-aft rigs reduced crew requirements (Castro *et al.*, 2008: 351). In order to obtain the advantages of both types of rig, many vessels employed combinations of the two. Barques, brigantines, barkentines and topsail-schooners are examples where fore-and-aft and square-rigged sails were combined.

Vessels often had their rig modified, even to the extent of removing or adding masts. Barques when sailing in the North Sea or Baltic, rather than the high seas, often had one mast removed, converting them to brigs, giving an adequate sail area and more open decks for 'local' operations. *Sprightly*, an Enderby-owned sealer, is listed in the 1822–30 issues of Lloyds' *Register of Shipping* as a Bridport-built single-deck ketch of 138 tons, drawing 11 ft (3.3 m) loaded. The *Register of the Society of Merchants* for the same period lists her as a sloop. In an anonymous painting of three Enderby vessels she is rigged as a topsail schooner. It is possible that all three descriptions were correct at different times, although 'ketch' usually refers to a smaller vessel, and a single-masted sloop-rig on a vessel of *Sprightly*'s size seems unlikely. Likewise, *Hetty*, a sealer in Antarctic waters in 1821, is recorded by a member of her crew as a schooner (Smith, 1844: 157), but in Lloyds' *Register of Shipping* as a brigantine. Conversion from brigantine to topsail-schooner merely involves removal of the fore-course square-rig sails, the lower staysails between the masts, and their replacement with a fore-and-aft foresail. It is quite likely that *Hetty* carried both rigs at different times. Fore-and-aft rigs were popular in the sealing industry, which required manoeuvrability in uncharted coastal waters, in poor weather, and with small crews. Whaling ships, with an entirely different set of requirements, were usually larger and square-rigged.

Cordage excavation techniques

In order to obtain information about rigging, we need to develop excavation and recording techniques. The first point is that an excavation system where divers are not working on their own area and features will seriously militate against effective recording. It is frustrating and disheartening to see hard rigging objects brought to the surface by others, lacking the associated cordage elements which had been so carefully uncovered earlier. Excavating rope under water will slow the excavation, but this need not be slower than any other area which is relatively delicate. When rope is first encountered, do not assume it will only be a small piece, or by the time its bulk is revealed the first parts may have been damaged or destroyed.

Early recognition and keen observation are key. We are dealing with ephemeral items, the most subtle parts of which—connections and associations; which bit joined to what, which passed around or through—are among the most important and most easily destroyed before being recorded. Assume that it will turn into a significant piece of cordage and tag, photograph, survey, and protect it, then proceed with excavation. Bandages and plastic net bags are excellent for protecting rope-ends. Try to keep sediment protecting the crown of the rope if possible, and supporting sediment beneath. Major dangers to cordage excavations are weed-clearance from trenches, and the fin-strokes of passing divers. Visible tagging, and temporary covering, are helpful if the rope is fully uncovered. When excavating cordage in sand, use gravity, and allow the sand to fall away, but try to leave the cordage supported until it is ready for removal. In clay, use fingers. Do not use a trowel, and, especially in clay, only expose as much of the rope as necessary to follow it.

Underwater photography of cordage in clay is difficult. Tagging can help to identify individual ropes. When ready to sample, remove the clay and rope as one and tag the broken ends. Guttering bound with crepe bandage is ideal as a support. Do not try and expose the whole rope under water; if the rope is becoming an obstruction, sample, record, re-tag and remove that section. Provided each section has identifying tags which have been surveyed in, the whole assembly can be plotted later on land. Avoid abrading cordage, because it will quickly lose its cohesion. If a portion does become abraded, try to reinforce and protect it. Use hands to wobble, or gently fan, the sediment or use a small wooden pick; never use a brush.

Recording

Firstly, a brief review of what has been done by others. Following Dixon, Hurley (1979) developed a formula system which, like others before him, used the letters S and Z to denote twist-direction of cordage elements. He also applied a numerical system of classifying cordage types. This has the advantage of brevity, can potentially record constructions for which we have no accepted definition, and the notational systems are elegant to algebraic minds. However, they can be difficult to read or enter into a computer, they are prone to errors in writing, and we normally find we need a verbal definition of what we record. The system becomes even more unwieldy if one attempts to include diameters, circumferences, angles of twist, cores, and items such as serving. Schjølberg (1988: 76–7) adopted a similar system, and had to devote two pages to explaining it, and her use of the terms ‘Stage II cordage’ and ‘ply’ is extremely confusing. Wendrich (1991) further developed notational recording-systems for both cordage and basketry, which non-mathematicians, in my experience at least, find non-intuitive, unnecessarily abstract, and difficult to visualise. Although it would be possible to indicate notationally, neither she nor Veldmeijer (2005) clearly shows whether yarns in strands have been laid or are only formed. Interestingly, a number of their ancient Egyptian cordage types, and one of those recorded by Ryan and Hansen (1987: 28 no. V) are strands (uncompleted, unstable cordage), which were either in preparation or had been unlaid for some reason. With post-medieval rope made on a ropewalk, standardisation is such that forming falls within the definition of the term ‘strand’. Arguably these notational systems are over-complex and deter recording before it has even begun.

The desire was to produce a recording-system which followed the structural conventions and component names of late-medieval and post-medieval rope, in a logical and unambiguous manner which could be quickly understood by non-specialists, which was compatible with computer spreadsheets, and which could act as an *aide memoire* for those needing accurately and quickly to record all the elements of twisted cordage and anything protecting it. My conclusion is that spreadsheet tabulation is the only way to set out all the information clearly and simply. It can still be reduced to an algebraic form if desired. The precise contents of the record-sheet would need adapting to suit the structure of medieval, classical and Asiatic cordage. This would probably involve changing some structural names, and at each level having an additional column to denote whether successive elements had been laid or formed, with an additional column to allow for plied yarns.

In collaboration with Elisabeth Veyrat, co-director of the excavation of the wrecks on the Natière reef, and an archaeologist with the Department of Underwater Archaeological Research, French Ministry of Culture (DRASSM), the current French recording-form evolved, and has been used on site for two seasons. The English version is illustrated (Fig. 6). Recording requires the systematic untwisting, counting and measurement of each element of a sample of the cordage—often a less-than-stimulating task. CAT-type scanning may prove possible for items which it is wished to conserve for museum display, but presently if the internal structure of an item of cordage is to be recorded with certainty, it has to be at least partially destroyed.

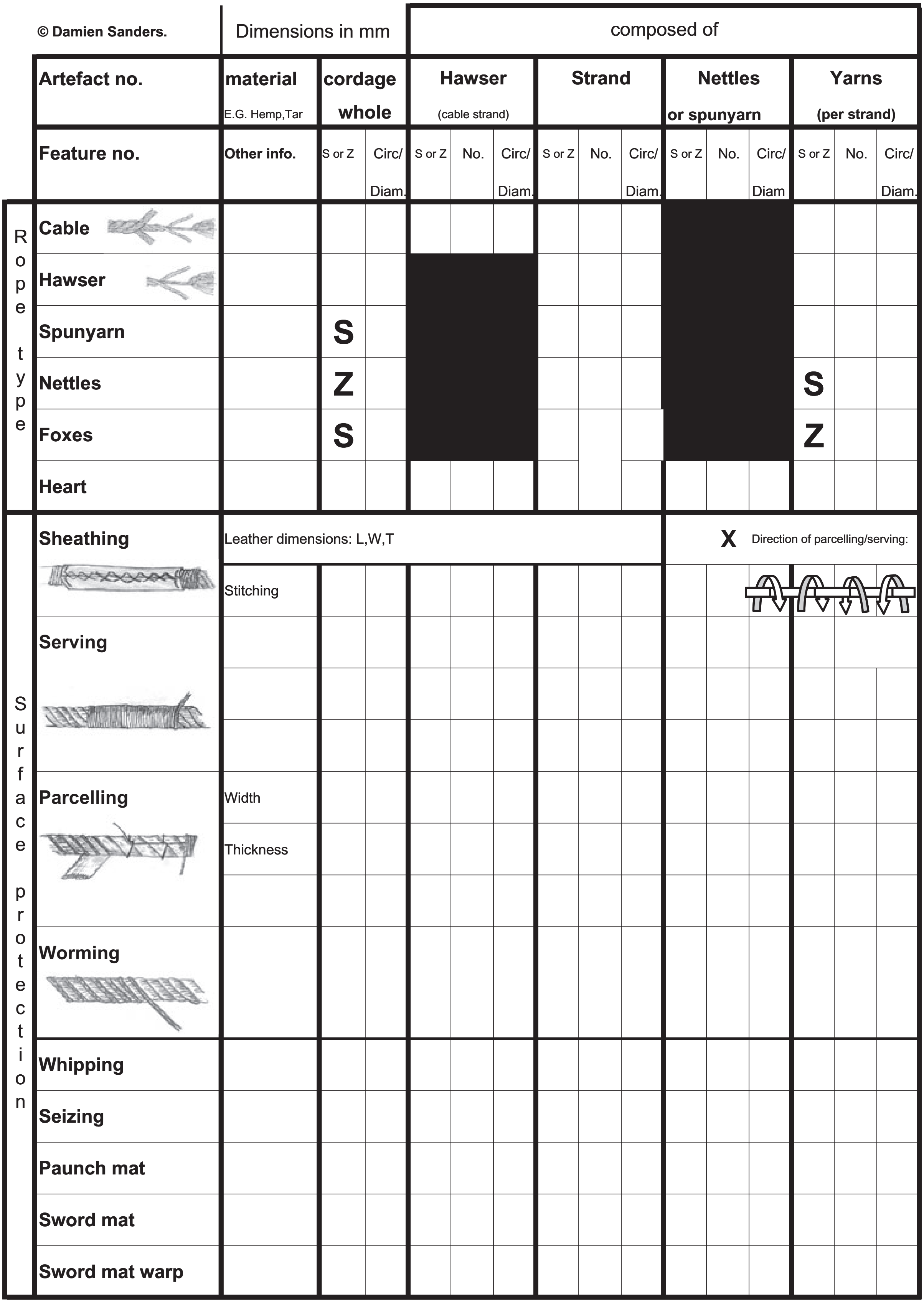
Cordage is first identified in the left-hand column as either a cable, a hawser, and so on. In the row relevant to that cordage, the twist-direction, number, and diameter or circumference of each element is recorded in the appropriate column. Below that, any form of protection or associated rope attachments can be recorded. A simple sketch of each term is designed to guide the person completing the form. The illustration (Fig. 7) of a forestay from *L'Aimable Grenot* with its record-sheet demonstrates the process. This is an exceptionally-complex 4-strand cable which has been wormed, parcelled, given three layers of progressively thicker serving, and covered in a 3-mm-thick layer of leather sheathing. The cable itself was 54 mm in diameter, while the entire assembly was between 80 and 105 mm in diameter, the difference being made up of the protective and stiffening coverings.

A brief note about measurement is necessary. Late-medieval rope was sold by weight, and little or no work has been done to determine what the standard length was, or to convert weight into circumference or diameter. Circumference was the main post-medieval way of recording rope, but it is easier to visualise a diameter. However, distorted rope and large cables, can only be measured accurately by circumference. This may not be practicable with very fragile rope, and a mean of several diameters, measured with vernier scales at 90° to the rope across two different strands, may have to do. My recommendation is to measure and record both, or to measure circumference and convert it to diameter ($C \div \pi$) but to indicate when any measurement is a conversion.

As well as its overall structure, the quality of the yarn and the various twists put into a rope during manufacture affect properties such as strength, flexibility and handling. The size and quantity of hurds (woody stem material) affects quality, as do fibres from inferior materials. In order to be able to reconstruct a rope, or assess the quality of its construction as part of future analysis, it is necessary to be able to measure the following: the angle of the strands' cantline to the rope axis; the angle of the yarns within that strand; and the angle to the axis of the yarn fibres themselves. This has been omitted from the sheet for two reasons; there was no room, and the measurements are fiddly. Wendrich offers mathematical ratios of diameter to twist which she terms the 'Cord Index' and 'Ply Index'. I would suggest that these are unable to provide the information required. The precise methodology for recording this information needs to be discussed further.[1] As a quick pragmatic solution, digital macro images of each find can be used in addition to standard photographs. Use a scale and an ID number, which will make any inadvertent flipping of a digital image immediately evident (flipping an image will turn a Z-twist cordage into an S-twist). A protractor or some means of showing the various angles may be useful. Original photographs for archiving should be taken in RAW format, possibly in the future in DNG. Saving in JPEG format means that with each image manipulation, up to 30% of the image data can be deleted, which will very quickly remove the definition needed to see the twist of yarn fibres.

Recording hard rigging elements

These should be recorded as soon as possible after recovery. The recording form illustrated (Fig. 8) should assist with this. In addition, the following should be recorded: the wood species for each element, how the wood for the block and sheave has been converted, and from where on the trunk it was obtained. Note whether the block is stropped, and its position *in situ*, and look for signs of wear. Was it in storage, or part of the rigging? On HMS *Invincible*, wrecked off Portsmouth, the rigging-stores were excavated (personal experience). The rope coils were so well preserved that in some cases only air-drying was required. Blocks were sold largely to Chatham; some others went to local pubs. At some point in the process at least one new block from the stores was stropped crudely with some rope from the stores, sold to Chatham as an element of rigging, and the deception was not spotted until Des Pawson noted it during an NAS Part III cordage course at Chatham in 1997. It pays to know what you are looking at.



© Damien Sanders.		Dimensions in mm			composed of											
	Artefact no.	**material** E.G. Hemp,Tar	**cordage whole**		**Hawser** (cable strand)			**Strand**			**Nettles or spunyarn**			**Yarns (per strand)**		
	Feature no.	**Other info.**	S or Z	Circ/ Diam.	S or Z	No.	Circ/ Diam.	S or Z	No.	Circ/ Diam.	S or Z	No.	Circ/ Diam	S or Z	No.	Circ/ Diam.
Rope type	**Cable**															
	Hawser															
	Spunyarn		**S**													
	Nettles		**Z**											**S**		
	Foxes		**S**											**Z**		
	Heart															
Surface protection	**Sheathing**	Leather dimensions: L,W,T										**X** Direction of parcelling/serving:				
		Stitching														
	Serving															
	Parcelling	Width														
		Thickness														
	Worming															
	Whipping															
	Seizing															
	Paunch mat															
	Sword mat															
	Sword mat warp															

Figure 6. The English rope-recording form. (ADRAMAR, D. Sanders)

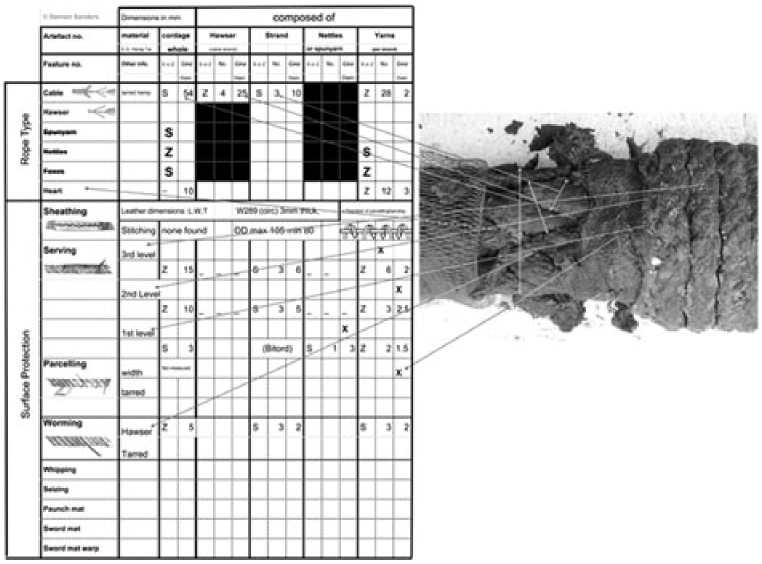
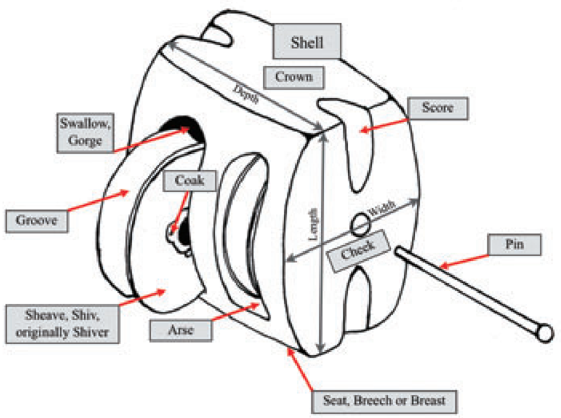


Figure 7. Rope-recording-form for Nat 2407 (Natière 2, *L'Aimable Grenot*) showing the forestay and the system of measuring. (ADRAMAR, D. Sanders)

PULLEY BLOCK COMPONENTS AND RECORD SHEET.



Artefact no. Block	Feature no.	Associated Artefacts

Measurement	Shell	Sheave slot	Swallow	Pin	Sheave	Groove	Score
Length							
Width							
Depth							
Diameter							

Number of Sheaves		Strop type (Single, double, pendant, etc.)
Number of Scores		

Component	Wood type	Timber conversion	Tool and wear marks
Shell			
Sheave			
Pin			

Figure 8. Block-recording sheet. (D. Sanders)

Analysis and conservation

On the Natière project, it was particularly useful that we had conservators on hand who were also divers, and diving archaeologists who developed specialisms, such as cooperage, rigging, hull-structure, and concretion-casting. This meant that people with particular expertise, and the conservator, could become involved with a find at the discovery stage, and follow it through every subsequent stage. As has been noted, masts and yards seldom seem to survive. Concreted iron rigging-fittings are found, although under water the content of most concretions is indistinguishable. At present, while smaller items can be recovered, X-rayed, and if possible conserved, or resin casts taken of the concretion, larger items are too bulky, heavy and brittle to be lifted and X-rayed. This is a shame, because there is almost certainly a great deal to be learned from the development of iron fittings for the standing rigging.

Try to maintain the cordage in the conditions under which it was found. If wet, then keep it wet, with the temperature as low as possible without freezing. Old, untarred rope in warm water rapidly ferments into a stinking mush. Tarred rope can be kept wet and wrapped in clingfilm for a number of years without deteriorating significantly, even without being refrigerated. Heavily-tarred rope was tarred in order to preserve it. Generally it will have remained well preserved, and a gentle washing in fresh water followed by slow air-drying may be all the conservation it needs.

Any study on the structure of the rope should be undertaken on samples as soon as possible. Conserved rope is very difficult to study effectively. It becomes rigid and fragile, and its dimensions change (Peacock and Schofield, 1996). C. Wayne Smith and Helen Dewolfe at Texas A&M University have apparently recently improved conservation of rope finds from *La Belle*, leaving it pliable and handleable, and easily recorded (pers. comm. O. Pipping). Photograph the sample, possibly make 1:1 drawings, or schematic diagrams of its construction. Take samples for chemical analysis and fibre identification (there may well be more than one fibre species present). During the dissection, record each element on the record-sheet and photograph each dissection stage digitally. If you do not understand what you are looking at, ask someone who does, for example a member of the International Guild of Knot Tyers; or consult Ashley's *Book of Knots*. If there is a knot in cordage, calling it a 'feature' is not helpful—identify it, find out what it was for, and give it its name.[2]

Whatever treatment is used, great care must be taken not to abrade the surface, and to keep the rope from untwisting. This care should begin during excavation. Bandages and plastic tube net bags are effective at holding rope-ends together and preventing fraying, both under water and after recovery, with the proviso that crepe bandages rot within about 2 weeks. Sediment must be removed. For cleaning on land, the most effective and least damaging is a fine (pin-head) jet of water, rather like a dental jet (a finger over a hose will work, with care). Conservators often instinctively reach for brushes. Discourage them; it irredeemably abrades the surface. Sediment between the fibres will destroy the rope's integrity when it is preserved. Some forms of cordage conserve better than others. A tarred, served cable will probably produce reasonable results. An untarred, loose-jawed rope covered in fine sediment is unlikely to be conserved successfully, especially with freeze-drying. Folded sails tend to end up looking like cow-pats, and techniques need improving. In the interim, it may be preferable to keep folded fragments wet and cold, as with ropes. Send the completed rope record-form with the artefact to the conservation lab, along with any photos of it *in situ*, to help them understand its original shape.

The intention is that by using the record-sheet non-specialists will be able to record full details of the construction of samples of rope quickly and completely. Although the recording process involves the destruction of a sample of the rope, in combination with the site diary, finds-sheets, dive-logs, sketches, and photographs taken during excavation, this sheet will provide a full record sufficient to reconstruct what was found. In some cases this may be more effective than attempts to preserve degraded rope, and less costly. Olof Pipping, who undertook the study of the rigging of *Vasa* and preliminary work on that of the *Mary Rose*, and the author, are of the opinion that the next stage of the analysis is to create a spreadsheet of all the rigging elements found, with their dimensions and locations. The process of analysing what originally went where on the vessel can then begin. Ultimately this should also give information as to what collapsed when, during both the wrecking and the subsequent site-formation processes. In due course it is hoped that an internet cordage and rigging discussion forum can be established, and hopefully this will lead into the development of a web-based reference database of rigging, in which the data from various wreck-sites can be collated for comparative purposes.[3]

Major unanswered questions

Marine archaeological sites could help fill some of the gaps in our broader knowledge of the history of rigging and cordage.

Materials and processing methods

The main materials used in European medieval and post-medieval ropes were the underbark or bast of small-leafed lime (*Tilia chordata*), horse-hair in Scandinavia in Viking and medieval times, hemp (*Cannabis sativa*), flax (*Linum usitatissimum*), and esparto grass (*Macrochloa tenacissima* or *Stipa tenacissima*) in the Mediterranean. Sometimes these were mixed, either legitimately or fraudulently. As far as is known, manila (*Musa textilis*), sisal (*Agave sisalana*), and other materials were introduced only in the 19th century. There was a major north-European shift from lime-bast to hemp in the mid- to late-13th century. Around the turn of the 14th century, the spinning-wheel was introduced, and in ropemaking the ropewalk progressively replaced the use of a reel and hand-laying cordage, although this ancient technique was used for some of the ropes on *Vasa* (pers. comm. Pipping, from O. Magnus) and was still being used on Scandinavian farms in the mid-20th century. Hand-laid rope has a distinctive end, comprising a doubled-back bight with a butt-end laid in-between. The lay also differs from cordage laid on a ropewalk.

Exactly when, why, and how this shift occurred is not known. Hemp is certainly more compatible with ropewalk machinery than some of the other materials in use at the time. It has a long staple, spins easily, and forms strong coherent yarns which will transmit the twists imparted by machines over a long length of yarn without breaking. Nor is it known how closely it was associated with, or driven by, the rise of the Hanseatic League, the deployment of multiple masts, and the development of more rigid hull-forms. Small-leafed lime is a sub-boreal tree whose product is strong and waterproof. However, it requires coppicing, and the stems allowed to grow for about nine years before they can be felled and the bark peeled off to process the bast. Microscopic analysis of bast cordage can also reveal whether the bast used was the less-flexible, weaker, but cheaper bark-bast, or the more valued trunk-bast (Pittam, 1996: 21–6). This long cultivation period, together with the climatic limits to its propagation, will probably have restricted the ability of bast production to meet the increased demands for cordage with the introduction of multiple-masted vessels. Mechanisation to meet increased demand may in turn have led to a search for machine-compatible raw materials. Flat bast does not spin easily. Another factor may well have been the north European adoption of sheaved blocks, because relatively-rigid lime-bast ropes may not have run freely enough around the pulleys. Little is known about the evolution of the pulley, nor of the dissemination of this knowledge through northern Europe.

Provenance (trade)

Little is known of how lime-bast was traded. Work at Bryggen, Bergen, in the 1980s (Schjølberg, 1988: 124–5) showed the evolution of cordage-types through the medieval period, and an interesting shift in processing techniques for lime-bast in the early-14th century, apparently to make it more supple, possibly because of the introduction of pulleys, possibly to imitate the qualities of a new competitor, hemp, or to make it usable on ropemaking machinery. It may well be worth re-examining these samples structurally to see if they were made on a ropewalk. It is probably no coincidence that the best hemp was grown in the same Baltic towns which were at the heart of the Hanseatic trading league. Hemp could sometimes provide two crops a year, and its rope was strong, flexible, and easier to make in large quantities than lime-bast. It was needed because of the large number of ships, and although hemp is less durable than bast when wet, a means of preserving the standing rigging was also at hand in the form of tar obtained from Baltic pine forests. Information from medieval wrecks could greatly help with turning such speculation into fact.

Evolution of rigging technology

The late-14th to late-15th centuries saw a north European revolution in hull-construction and in rigging and sail technology, which was the equivalent of the shift from wood to iron and then steel, and from sail to steam in the 19th and early-20th centuries. Presently most discussion centres around hull-structure, but larger vessels are useless unless they can be propelled and controlled, which requires multiple masts and increasingly complex rigging and sail-types. The details are still not fully known, nor the practical and economic needs which drove the process, nor the cultural routes of its transmission (I personally suspect that the Iberian peninsula, and the Basques in particular, may have been key elements). Sail and rigging technological development is particularly poorly understood.

The Mediterranean development of the lateen sail (Whitewright, 2008), and much later multiple-masted ships, followed by the integration of the lateen-sail tradition with the north European square-sail, and the development of top and topgallant masts, is all a part of this process. This development was in turn limited by the strength, durability and reliability of the cordage, about which we know little, and by the stresses these masts and rigging imposed on the hull, which needed to become sufficiently rigid in structure to support the increased spread of sail and to allow increasing vessel-size to take advantage of the possibilities which the developments in rigging presented. It seems pointless to study one without the other. It is pleasing that the recent publication of the Red Bay site in Newfoundland devotes 30 pages to 'Rigging and Deck Hardware', and ends its first paragraph by saying 'Excavation and analysis of the large number of fittings and rigging components from Red Bay has led to a better understanding of 16th-century seamanship and seafaring technology' (Bradley, 2007: 1).

Regarding another 16th-century wreck, it is not improbable that the *Mary Rose* sank with another rig than the one she had when newly built. Rigging needs to be renewed regularly and it is clear from the rigging inventories and iconographic evidence that over her lifetime the rig of ships was evolving rapidly, the adoption and perfection of topgallant masts being one example. Another example, which appears to have gone unnoticed, is that in the 1514 inventory the main mast is listed as having 13 shrouds on each side, whereas only 10 mainmast deadeyes and chains were found on the wreck (Marsden 2003: 168, fig. 11.19). The process of reducing the number of shrouds on masts for vessels of comparable size is evident in the iconographic, model and archaeological evidence from the late-15th to the early-18th century. Since masts were becoming taller and upper yards larger, it suggests a rationalisation made possible by improvements in rope quality. This has not been systematically studied archaeologically.

The forthcoming hull and rigging volume of the *Mary Rose* and the rigging volume of *Vasa* will hopefully provide some fascinating insights into the evolution of rigging and its adoption aboard these vessels. Future discoveries and excavation will hopefully yield finds from other kinds of ships, especially merchant ships, which will provide other perspectives. For example, the systematic study of the *Vasa* cordage has shown the co-existence of 'medieval' and 'modern' technologies, as well as a wide variation in the quality of workmanship, from the processing of the raw material to the spinning of yarn, to the final polishing of the rope. The picture of industrial production as presented in du Monceau may only be a partial picture of contemporary ropemaking (pers. comm. Fred Hocker).

Traditions, standardisation, technological change, specialisation

It would seem that French rigging traditions were at times quite distinct to British ones, and possibly diagnostically so. Did both nations re-rig captured vessels? What is the origin of these various traditions, how did they evolve, and what degree of standardisation existed? For William Watson (a merchant, not a rigger) to be based in Danzig (Gdansk) in the 1540s receiving orders from Sir Thomas Cavernden from the Privy Council in England (British Library, 35 Henry VIII 5752.f.29–32) and obtaining large numbers of rigging items (primarily spars, cables and other large cordage) for English warships, there must already have been a high level of standardisation for at least certain categories of cordage by the mid-Tudor period. Evidence of standards can be seen in the collection of rigging items from the *Mary Rose*, which also show that blocks were technically equal to blocks made 300 years later, but fashioned to correspond to an earlier design pattern.

Most people are aware of Brunel's Block Mills, but what were the economics of the rigging-supply industry, and how did the supporting technologies evolve? The development of block morphology across Europe from the 14th to the mid-17th century is not well documented. The two blocks and one heart from the mid-15th-century Newport ship are simple, with a small sheave, and rather imprecisely made, yet they strongly resemble some of those found on the *Mary Rose* (1545) and even on the *Vasa* (1628). Others from these latter vessels look rather more modern. Those found on the wrecks from the battle of La Hougue (1692) look to the casual eye like any 18th-century block.

As regards cordage, there is a developed folklore about burst yarns on large ropes due to uneven tensioning during the processes of laying-up and closing. Is this real, is it mythology, and if it was a real problem, was it inevitable? Only examination of real ropes will tell us. There is evidence that hawsers greater than 9 inches (229 mm) in circumference (73 mm diameter) were probably difficult to lay with an even yarn-tension because above this size yarns became unequally tensioned; those on the inside were loose and puckered, those outside had a tendency to burst. This was solved by the introduction of the register-plate and forcing-tube in the 1790s for adjusting yarn-lengths according to their final position in a rope. Chapman (1808: 14) cites a resulting reduction from 10-inch-circumference rope down to 7-inch-circumference for the same strength of shroud. Tyson (1966: 10) states that the use of the register-plate in forming a strand increased strength by at least 50%, and some sources claim almost 100%. Prior to this, one purpose of cables was as a means of constructing rope too large to be made hawser-laid. Du Monceau (1769: 320–21) is quite explicit about this. The bursting problem probably occurred in hawsers larger than 9 inches (229 mm) in circumference or in cables whose component hawsers approached this size. Why cablets (cables smaller than the maximum size of hawsers) were made has not been fully explained.

The anchor-cable of the *Mary Rose* appears to be evenly tensioned throughout, suggesting either

Figure 9. Leading block 2231 (Natière 1, *La Dauphine*), and shroud. (ADRAMAR, T. Seguin)

a high degree of skill, or possibly some early form of registering the tension of each yarn. In contrast, I have encountered only one rope from a shipwreck whose central yarns were puckered while the outer ones appeared stretched (perhaps due to either uneven tensioning or a broken yarn), though Ole Magnus found a number in the *Vasa* rigging. Experimentation coupled with examination of archaeological material could help us to distinguish between poor workmanship and deficiencies in the available technology.

A number of the ropes I have dissected and recorded, including the anchor-cable from the *Mary Rose*, have differing numbers of yarns in their strands. When the difference is only one yarn, this could be explained by either manufacturer's or recorder's error. However it is not uncommon to find each strand having different yarn numbers, sometimes by as many as two or three. At present it is uncertain whether this is fraud, or an attempt during manufacture to compensate for differing yarn-sizes, which may be an indication of poor control of yarn production. Information, as yet only apocryphal, suggests that different ports and roperies produced rope of differing quality. In northern France, St Malo rope was reputed to be poorly made. Hemp certainly varied in quality around Europe. It would be interesting to see whether scientific analysis could provenance the hemp from which rope has been made. Other factors which may not be detectable archaeologically include the quality of fibre and yarn produced, and practices such as twice-laid rope—recycled yarn from old rope. In discussing the factors listed above Des Pawson (2007) has indicated that these differences are significant, but their consequent effects on the design of the rigging are not fully known.

Construction techniques

Stays and shrouds

Again there is likely to be a discrepancy between treatises, folklore, and everyday practice. We need to build information about what practices were, at different periods, among different nationalities, on different types of vessel, and with different rigs. Archaeology is critical in verifying this information. Shroud-laid ropes, for example, were traditionally 4-strand with a central heart. Some larger vessels are supposed to have had cable shrouds. The shrouds of the Natière wrecks varied, depending on their position on the ship. *Dauphine*'s fore-topmast shrouds (Figs 9 and 10) were 3-strand hawsers; some of the backstays may have been the same, while some associated cables are thought to be stays or backstays. The foremast shrouds of *L'Aimable Grenot* were shroud-laid, while those of the mizzenmast were mostly 3-strand hawsers, with the exception of one which had a shroud knot joining it to a 4-strand shroud-laid rope, which will be discussed in a future paper. The served mizzen backstays were cablets. All of these, and the lanyards to the deadeyes, were heavily tarred. This indicates a degree of diversity far removed from neat academic classifications. The reality found aboard *La Dauphine* and *L'Aimable Grenot* is perhaps borne out by du Monceau (1769: 315 XI), who states that shroud-laid ropes are common in some ports and not

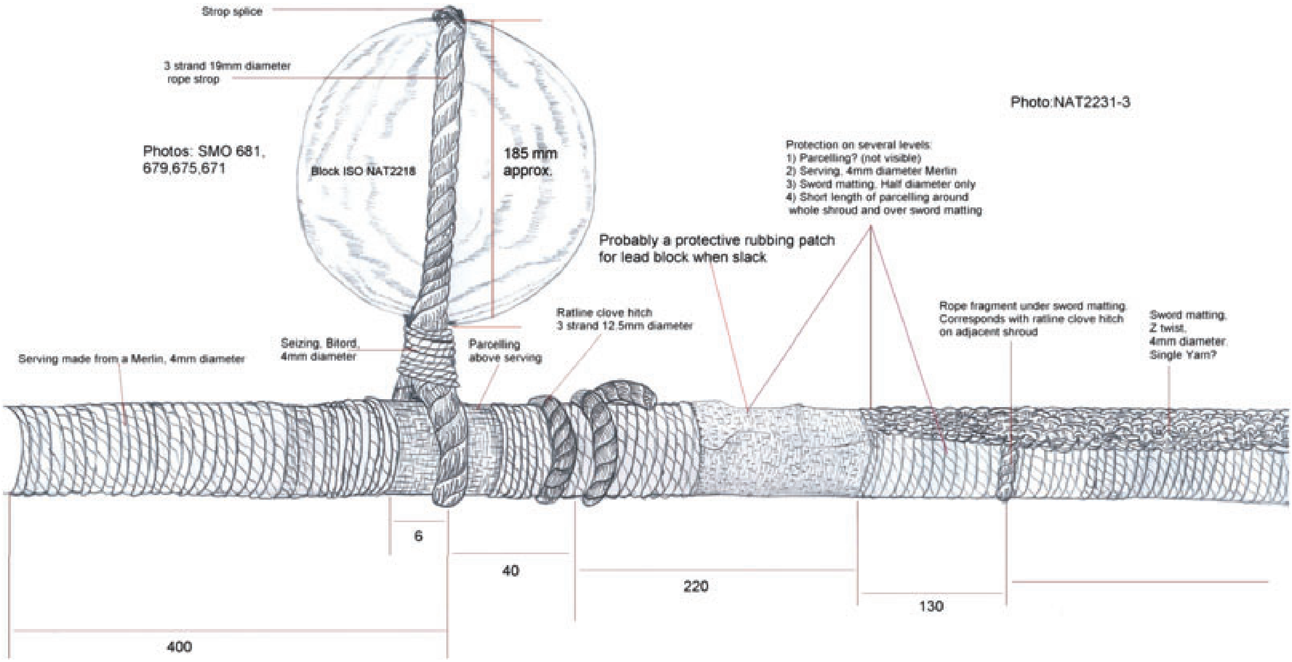


Figure 10. Schematic drawing of the block in Figure 9. (ADRAMAR, D. Sanders)

others, depending on local belief. Du Monceau was trying to quantify these beliefs with scientific testing. In 1677 Dassié wrote that in France 'the main shrouds, the fore shrouds, and the others, ought to be of three strands' (1994: 53).

Worming, parcelling, serving, sheathing

I had assumed (from reading 19th- and 20th-century texts) that served ropes would always have been wormed and parcelled. Experience of the remains from *La Dauphine* and *L'Aimable Grenot* called this into question. Having looked at the cordage recovered from these two wrecks, referred to various sources including Mainwaring (1623/1922, National Archives SP16/127, dated 1628, but containing some older documents), Lescalier (1791), and Steel (1794), and following discussions with colleagues Des Pawson, Graham McLachlan and Olof Pipping, it seems that worming was only used on the large cables (presumed to be stays). Parcelling seems to have only been used on items such as stays, collars and strops which were required to be particularly waterproof, durable and rigid. Quite possibly cost played a role; further study is needed to see whether the royal-built frigate *La Dauphine* from Le Havre had rigging elements constructed to a better standard than those of the privately-built *L'Aimable Grenot* from Granville. Even on the cable-laid mizzenmast backstays of *L'Aimable Grenot* there was serving but no worming, and the cable profile was clearly visible through the serving, indicating that it would probably not have been watertight. Perhaps the function in this case was chafe protection? Corder (2007: 158) notes the same absence of worming and parcelling on the served rope found on *La Belle*, which left France in 1684. The common assumption that all served rope was first parcelled and then served may well be based on 19th-century practice.

We need to examine everyday practice and contemporary theory and see how closely they match. For example, are the treatises, ship-models or 18th-century vessel paintings unanimous in stating or showing that forestays were wormed but never parcelled and served? This is not to say that *L'Aimable Grenot* lacked elaborate rigging. The forestay or forestay-preventer (NAT 2407) (Fig. 7), has already been mentioned. The load-bearing 54-mm-diameter cable at the centre was only a little over half the total diameter of the stay assembly. I have yet to find any reference to this or similar practices in contemporary sources. One of the few that even mentions serving and leather-sheathing in more than passing detail is the extremely rare Rajalin (1730).

As regards the ratlines, Anderson (1994: 130) states that the distance between ratlines is uncertain. He gives a series of archival and model sources which range between 12 and 16 inches (305–406 mm). Lees (1984: 44) gives the standard size of ratline rope as $1^1/_2$ inches (38 mm), and the vertical spacing between ratlines as varying between 13 and 15 inches (330–380 mm). Both state that in the later-18th century the ends of the ratlines were eye-spliced and seized to the shroud, although Anderson states that in the late-17th century this does not appear to have been the case. Ratline clove-hitches were found on the mizzen-mast shrouds of *L'Aimable Grenot* and on the fore-topmast shrouds of *La Dauphine*. On a single shroud the distance between clove-hitches will be greater than the vertical separation between ratlines due to the spread of the shrouds. However, the spacing on *La Dauphine* (1704) was 350 mm, and on *L'Aimable Grenot* (1749) 400 mm. Some of the hitches found had sword-matting covering them, and none of the ends of the ratlines was attached by means of eye-splices and seizings. This is a very limited sample, and it would be nice to be able to add data from other wreck-sites. Recognition is the key. None of my colleagues recognised clove-hitches under water, and most of them found it difficult to see them on the shrouds which were recovered to the surface. Archaeology has the potential both to confirm the correlation between contemporary theory and reality, and to fill in gaps which theory does not touch.

Liquid protective coatings

Modern chemical analysis of samples could identify traditional uses of these materials, and if the context is properly recorded, where their use was preferred. Tallow, pine-tar, beeswax, linseed-oil and lanolin have all been used on rigging elements. Which were used when, where, and by whom? What is their provenance, and what can be learned of the trade in these substances? This has been discused by Loewen (2005) and Pawson (2007), but we have little archaeological data. A further question is that while tar was essential to prolong the life of hemp cordage, it reduces its strength. Chapman (1808: vi) states that a 3-inch (76-mm) circumference rope tarred with common pine-tar broke at 3848 lbs, while the same rope tarred with teak-tar broke at 5980 lbs.

There are issues in this respect with the presentation of the rigging on HMS *Victory*. There is a popular wisecrack within naval circles that 'if it doesn't move, paint it'. Until about 20 years ago, this had happened on *Victory*, so all the standing rigging, and such running rigging as was fitted, was tarred or painted. Realising that this was incorrect, someone seems to have defined running-rigging cordage as all ropes which were moved or adjusted aboard ship. I have been unable to establish who, or the historical basis on which the decision was made. This definition apparently included bowsprit-gammoning, ratlines, deadeye-lanyards and the anchor-cable, because the replacements for these were 'untarred' (buff-coloured synthetic rope). The result is that tourists see *Victory* resplendent in her imitation-hemp rope—black staple polypropylene for the 'tarred' rope and fibrillated polypropylene synthetic hemp in white for the 'untarred' items. This new and quite unhistorical practice has now spread to film and television.

It is demonstrable that if unprotected hemp is continually wetted and dried it changes in size, tension and strength, and will quickly rot. Du Monceau quantified this as early as 1748. I have excavated at least five ship's anchor-cables, and know of at least a couple more. They include English and French men-of-war and merchantmen, ranging in date from the mid-16th to the mid-18th centuries. All had been heavily tarred. Equally, I have excavated deadeye-lanyards, stay-lanyards, gammoning and ratline clove-hitches from several wrecks. It is unclear whether these had been tarred during manufacture, but they were unquestionably tarred after they had been fitted and tensioned. The possible exception is the ratlines, which may not always have been tarred beyond the shrouds. On the two Natière wrecks where tarred clove-hitches were found around the shrouds, only a few rotten fragments of the main lines survived, and these may not have been tarred. Probably they were tarred, only less so, but confirming this would require chemical analysis.

Gun-carriage cordage

Again on *Victory*, below decks, all the gun-breeching-ropes are made from either left-laid or possibly reverse-laid ropes (see definitions above), as is the messenger for the anchor-cable. I have never personally found either rope-type on any wreck-site, and have not been able to discover when or where the decision to have these made specially for *Victory* originated. This goes back to at least the 1950s, when photographs of the quarterdeck show breeching-ropes which appear to be plain-laid (Z-twist hawser), but with S-twist ones on the main gundeck. In the mid-1990s all the gun-breeching ropes were switched to S-twist. More recently the anchor messenger-cable—which in the 1950s photographs was a cable—has been altered to an S-twist hawser (see earlier comments about the ability to make such ropes as hawsers in the 18th century).

I have been told, and Ashley (1993: 112) states, that backhanded or reverse-laid rope was used for gun-tackle ropes, and also hammocks, because it was less liable to tangle. Whether this is folklore, and, if not, when and how widely it was adopted, is something for archaeologists to help establish. Again, the only S-twist hawser-laid rope I have encountered is a short length found in the hull of the Newport ship. Currently both gun-tackle ropes and hammock-lines on *Victory* are made of hawser-laid rope. Iconographic evidence is totally unreliable. Even if the original drawing was faithful, both it and a subsequent photograph can get reversed during printing and copying processes. For example, there is a drawing from the *Illustrated London News* of 28 October 1876 showing one of *Victory*'s guns with S-twist breeching and gun-tackle rope. It has probably been reversed. Many of du Monceau's images are either re-engraved copies, or were not cut as mirror images by the engraver. Once printed, this has turned many of his workers into left-handers, and turned S-cordage into Z.

A photograph taken on HMS *Superb* by Nicolaas Henneman in 1845 (Science and Society Picture Library ref. 10323490), shows S-laid breeching-ropes which appear to be hawsers, not cables, around the 32-pounder guns, and Z-laid shrouds. Other Z-hawser-laid ropes in the image do indicate that in this case the print has not been reversed. An additional twist is the re-use of old rigging elements elsewhere on a vessel. John Sellar (1691: 162) states that a gunner's stores should include old shrouds for breeching and twice-laid stuff for tackles. Add this to the probable lack of standardisation of shroud cordage discussed earlier, and it suggests that a whole range of rope-types might be used on guns, and that the origin of the recent *Victory* tradition might be as simple as someone who could not distinguish a hawser from a cable lay.

We need to find gun-tackle and breeching-ropes *in situ* on archaeological sites. *Vasa* has both, and both are regular three-stranded, Z-laid rope (pers. comm. Fred Hocker). These items have also recently been found on *Stirling Castle* and *Northumberland*, wrecked during the great storm in 1703. The *Stirling Castle*'s breech rope is Z-laid hawser, as are the ropes associated with the tackles (McElvogue, 2008). The matter is important, because S-twist hawser-laid breeching-ropes have appeared on HMS *Warrior* and in association with the *Hermione* replica in Rochefort. If this has no historical basis, the spread of the 'contagion' needs to be stopped promptly, or S-twist hawsers of varying confections will be appearing all over the place, and at considerable uneccessary expense.

Conclusions

Study of rigging-elements and even fragments of rope from wrecks can give indications as to the size of the vessel, its age, its nationality, the type of trade in which it was engaged, clues to the wrecking process, and to post-wrecking processes such as salvage and site formation. More broadly, study of such rope and rigging could help us to understand the evolution of rope technology and rigging on ships in Europe, the Mediterranean and the Near East. This is especially true in the late classical and early Arab period (Whitewright, 2007; 2008); and again in the late medieval and early post-medieval periods. Such study would help us to understand traditions of seamanship and ropework, and national differences in the technologies. Unfortunately at the moment we often lack both the analytical techniques and the comparative background data from other wrecks fully to realise this potential.

This paper is largely an outline of what we need to find out, illustrated by a few examples. I believe that the examples are of value in themselves, but also that this value would be greatly enhanced by becoming part of a much larger data-set of rigging excavated from other wrecks to the same or better standards. On a personal and almost emotive level, I think that as archaeologists and historians we are the poorer if we are unable to engage with the dynamic technology which brought these ships to life and drove them around the globe (and sometimes onto rocks). Anyone who has stood on a square-rigged vessel, among the scent of hempen ropes, smelt the tar on their hands, felt the wind in their hair, heard it crack into the sail, and watched the ship bend and groan into life, will know what I mean. In attempting to do so, I make no apologies to long-suffering French colleagues who looked askance at my brown, soggy, almost fetishistic collections and disparagingly called them 'la soupe Anglaise'. On the contrary, some of them encouraged me. I hope this paper succeeds in persuading a few of you to take up the cause.

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Notes

1. The late Ole Magnus at Roskilde was one of the few people whose extensive study of ropes and analysis of archaeological cordage finds is informed by his ability to make the ropes he was studying.
2. Des Pawson, former president of the Guild of Knot Tyers, encourages archaeologists who have rope, knots or ropework needing identification or analysis to use him as a point of contact. His contact details are: Des Pawson MBE, 501 Wherstead Road, Ipswich, Suffolk IP2 8LL, UK; tel: (0044) (0)1473 690090; des@despawson.com.
3. The recording forms can be downloaded from the ADRAMAR website (www.adramar.fr), and a French forum for archaeologists has been established in the 'noeuds' section of the forum of the French International Guild of Knot-Tyers site at www.igktfrance.com. Ideally an English language website will be arranged: in the interim, myself, Des Pawson (see above) and Olof Pipping (olof.pipping@marotec.se), who both helped considerably with advice during writing this paper, are happy to be contacted direct.

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