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Roman Rigging Material from the Red Sea Port of Myos Hormos

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Excavation of the Roman port of Myos Hormos on the Egyptian Red Sea coast has revealed both the extent of the Roman harbour and a significant corpus of maritime artefacts. These include a relatively large quantity of rigging material such as brail-rings and sailcloth dating from the late-1st century BC to the middle of the 3rd century AD. These finds are important for our understanding of ancient shipping in the Mediterranean, Red Sea and Indian Ocean regions.

Key words: Red Sea, brail-rings, sailcloth.

In his wide-ranging commentary on maritime archaeology, Muckelroy (1978: 217) observed that the upper-works of vessels, such as oars, sails, and crew accommodation, would be overlooked because of their poor representation in the archaeological record. This observation has been largely upheld with regard to the shipping of the ancient Mediterranean. Over 1200 shipwrecks have now been investigated from the Mediterranean world (Parker, 1992), but reference to Parker's work reveals that the reporting and publication of rigging material has been sporadic and inconsistent. Consequently there has been a lack of considered, analytical investigation into the archaeology of the ancient sailing rig. Coupled with this, studies into the rigging of ancient ships have continued to rely on subjective interpretations of the evidence, such as iconography and ancient texts. As a result of this, our understanding of ancient sailing rigs has been unable to move beyond general observations because of the absence of widely-available archaeological evidence and the detail which can be observed within it.

This paper aims to add to the limited body of rigging material by presenting and discussing a recently-excavated, relatively-large corpus of rigging material from the Roman port of Myos Hormos on the Red Sea coast of Egypt. These artefacts can be classed as maritime because of their implicit association with the maritime activities of the site. The material published here dates from the late-1st century BC through to the middle of the 3rd century AD and includes a deadeye, sheaves, brail-rings and sail fragments. This material substantially increases and enhances the overall body of excavated material now available relating to the rigging and use of Roman-period sailing vessels in the Mediterranean and Indian Ocean regions. A full report and catalogue of the maritime artefacts from both the Roman and Islamic periods of occupation of the site is in preparation.

As well as providing an additional resource to existing published material, presenting the material from Myos Hormos provides an opportunity to compare and analyse rigging from the Roman Red Sea ports in relation to rigging components from the ancient Mediterranean. Such a comparison increases our understanding of the rigging-remains from both areas by placing them in their wider technological context. It also serves to highlight the usefulness of direct archaeological evidence in providing a detailed view of ancient technology over and above that derived from iconographic and textual sources.

Background and context

Excavation at the Roman port of Myos Hormos was carried out by an expedition from the University of Southampton between 1999 and 2003 (Peacock and Blue, 2006). The site, known locally as Quseir al-Qadim, is situated about 8 km north of the town of al-Quseir, on the Red

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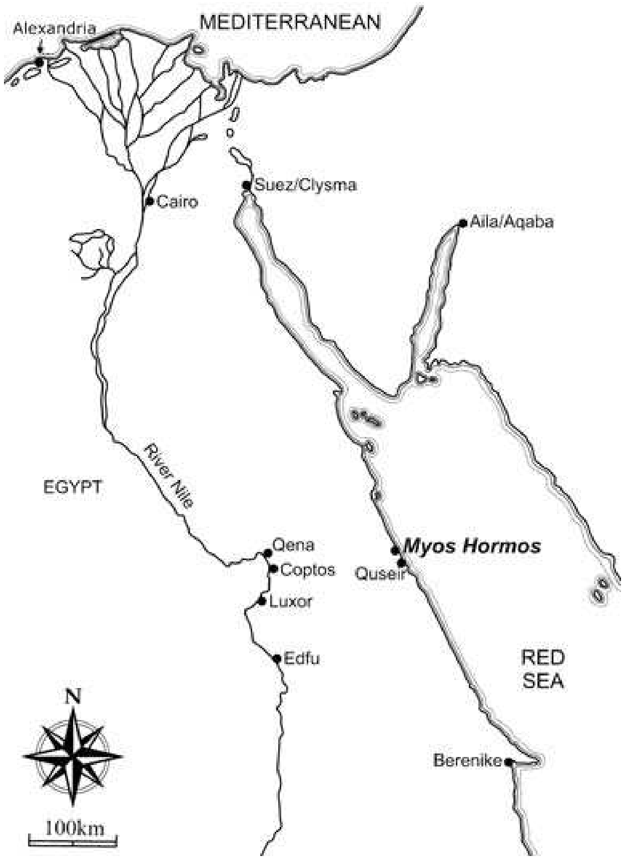

Figure 1. The northern Red Sea showing the location of Myos Hormos. (after Peacock and Blue, 2006: fig. 1)

Sea coast about 500 km south of Suez (Fig. 1). Much of the western shore of the Red Sea is formed by a raised coral platform which runs parallel to the shore (Davies and Morgan, 1995: 37). Myos Hormos occupies a position on this platform, which rises to about 8 m above sea-level (Blue, 2006: 43), forming a south-facing peninsula surrounded by the Red Sea to the east and a now-silted lagoon to the south and west. This lagoon, which would not have been silted in Roman times, was the location for the Roman harbour of Myos Hormos (Blue, 2006: fig. 4.13).

Myos Hormos itself is mentioned several times by a variety of ancient authors, most notably in the *Periplus Maris Erythraei* (Schoff, 1912; Casson, 1989), a 1st-century AD merchant's account of sailing from Egypt to India. The author of the *Periplus* (1:1–4) noted that, along with the port of Berenike to the south, Myos Hormos was a major port on the Red Sea in this period. Between them the two ports articulated trade directly between the Mediterranean, the Red Sea and the Indian Ocean and indirectly to lands to the East. Mediterranean trade with the Indian Ocean increased in the Roman period, witnessed by Strabo's statement (2.5.12) that 'Now 120 ships sail from Myos Hormos to India. Before, under the Ptolemaic kings, only a few vessels undertook to sail there and carry back Indian merchandise'. Berenike continued to operate as a port into the late-Roman period, while Myos Hormos declined during the 3rd century AD (Peacock and Blue, 2006: 4).

Rigging material

Given continuous maritime activity at the site from at least the 1st century BC to the 3rd century AD (Peacock and Blue, 2006: 174–5) it is perhaps unsurprising that the archaeological record of the port and associated settlement contained substantial evidence of maritime activity. Statistically, the bulk of the material came from the Roman *sebakhs* (rubbish-dumps) which are spread across the higher ground of the site. As such they have been deposited in a non-maritime context in a manner associated with discard following manufacture or use, rather than deposition during use. The combination of the arid local climate, a protective layer of sand, and having been deposited above the tidal water-table, has afforded much of the site a high level of preservation of organic artefacts. The finds themselves ranged in date from the late-1st century BC through to the middle of the 3rd century AD, which is consistent with the Roman occupation and use of the site. Maritime artefacts from the excavation included 169 brail-rings, a deadeye, various sheaves from rigging-blocks, and several fragments of sailcloth, which are described below.

Deadeye

A deadeye (Fig. 2) was excavated in the 2001 season and dated via associated material to the mid-to-late 2nd century AD (Thomas and Masser, 2006: 131–2). It consisted of an oval-shaped tablet of wood, pierced by three holes set alongside one another in the centre of the block. It measured 214 mm long, 144 mm wide and 55 mm thick, although the reverse side had been heavily degraded. The outside edge had been grooved in order to take a rope strop which could have been up to 28 mm in diameter. The three central holes could have carried ropes of up to 25 mm in diameter. It is likely that the deadeye would have formed part of a pair of blocks in the

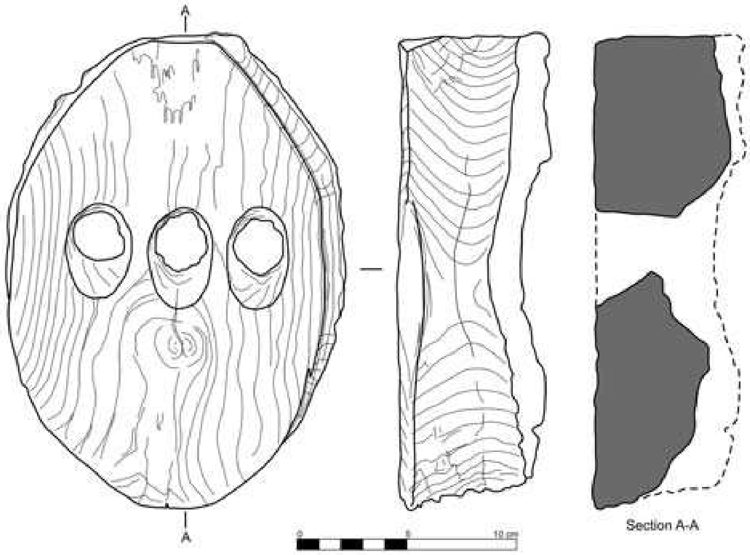

Figure 2. Roman deadeye from Myos Hormos. (J. Whitewright)

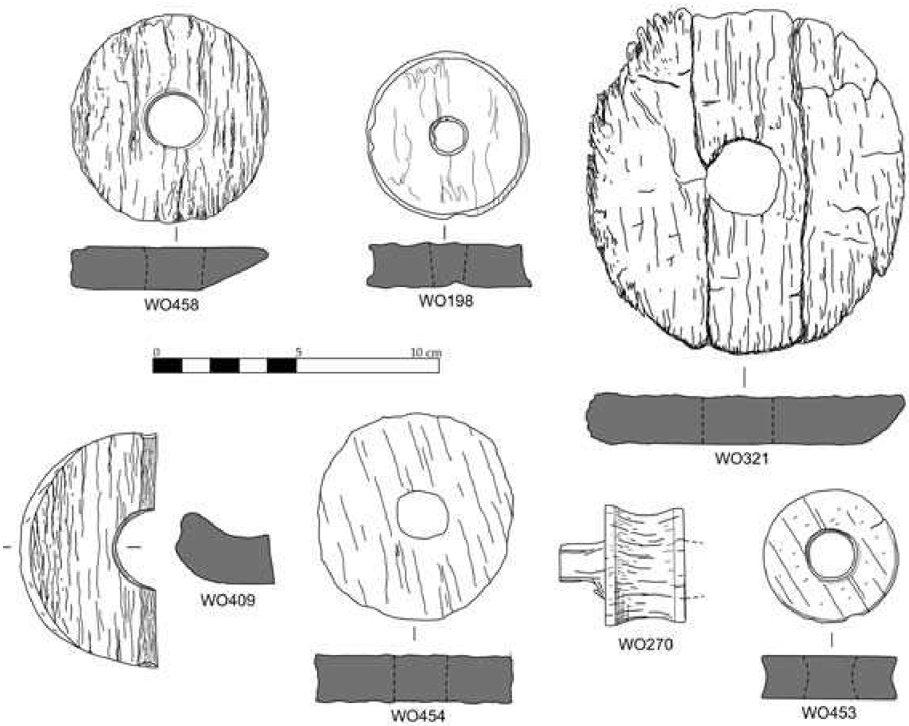

Figure 3. Roman rigging-block sheaves from Myos Hormos. (J. Whitewright)

shrouds of a ship, in much the same fashion as they do on modern sailing ships. Comparative examples of deadeyes from Mediterranean contexts have been excavated from shipwrecks at Grado (Beltrame and Gaddi, 2005: 80), Laurons 2 (Gassend *et al.*, 1984) and Nin (Enona/Plavac) (Brusic and Domjan, 1985: 81, fig. 6.9).

Rigging-block sheaves

Excavations in 2001 and 2002 also unearthed seven sheaves from several different rigging-blocks (Fig. 3). They all date to the second half of the 2nd century AD with the exception of one (wo198) which is Early Roman. Unfortunately, the finds consisted of the sheaves only; no shells or axles were found at all. Such finds would, being part of a block and tackle, probably have been used in some aspect of a vessel's running rigging. They could also have been used in other, non-nautical activities, such as moving heavy objects. It is therefore impossible to say definitely whether these objects were maritime in function. Six of the sheaves were flat, circular discs of wood and ranged from 46 to 81 mm in diameter. The outer edges, where not decayed, were grooved to carry the associated rope, while their thickness, and so the diameter of the rope they could carry, was very consistent at between 14 and 16 mm. This may indicate the use of a standard-diameter rope. It might be possible to account for the difference in sheave diameter by the use of bigger sheaves in blocks designed to resist higher loads. Comparative disc sheaves, or blocks using disc sheaves, have been excavated from the Cavalière (Charlin *et al.*, 1978: 57–60), County Hall (Marsden, 1974: fig. 8.2), Grand Ribaud D (Hesnard *et al.*, 1988: 105–26), La Ciotat (Benoit, 1962: 168–9, fig. 46), Laurons 2 (Ximénès and Moerman, 1990: 5–6, fig. 1), Madrague de Giens (Joncheray, 1975: 103), Port Vendres 1 and 2 (Liou, 1975: 572–3; Colls *et al.*, 1977: fig. 2) shipwrecks, and from a terrestrial context at the site of Kenchreai (Shaw, 1967: fig. 1). Disc-sheaved blocks are also visible in the depiction of naval spoils on the triumphal arch at Orange (Amy, 1962: pl. 25).

The seventh sheave excavated at Myos Hormos (wo270), although damaged, was clearly cylindrical and of the type associated with distinctively Mediterranean-style single-sheave blocks. Comparable examples of cylindrical sheaves have been excavated from the Roman harbour of Caesarea Maritima (Oleson, 1983; Oleson *et al.*, 1994: 104, fig. 33, pl. 22) and also from the Agde D (Liou, 1973: 578, fig. 10), Cap del Vol (Foerster, 1980: fig. 5), Chrétienne C (Joncheray, 1975: 103, fig. 50.1), Comacchio (Berti, 1990), Grado (Beltrame and Gaddi, 2005: fig. 2), Grand Ribaud D (Hesnard *et al.*, 1988: 105–26), Kyrenia (Swiny and Katzev, 1973: 351, fig. 12) and Tradelière (Joncheray, 1975: 103) shipwrecks. A sheave-block of this type was also recovered from a looted and dredged late-4th or early-3rd-century BC site in the Sea of Marmara (Pulak, 1985: 3). Wo270 represents the only evidence of the use of this form of sheave block at the site of Myos Hormos. The size of the sheave suggests a block of similar size to the block found at Caesarea Maritima; 130 mm long by 90 mm wide.

Brail-rings

Brail-rings were by far the most numerous class of maritime artefact surviving from Myos Hormos. They were excavated during every field season, principally from the Roman *sebakhs* which litter the site, and encompass the full Roman chronology of the site. The 169 brail-rings excavated can be classified into two groups; 118 were made from cattle-horn, and the remaining 51 from wood. The use of these two types of materials is consistent with finds of brail-rings from Berenike, which were also made from wood and horn (Wild and Wild, 2001: 214). An example of the wooden brail-rings is included here (Fig. 4) in order to illustrate their characteristics. Comparative examples of brail-rings, made from lead as well as wood, have been excavated from the Cavalière (Charlin *et al.*, 1978: 57–60), Grand Congloué (Benoit, 1961: 178–9, pl. 30), Grand Ribaud D (Hesnard *et al.*, 1988: 105–26), Kyrenia (pers. comm. Swiny) and Straton's Tower (Fitzgerald, 1994: 169) shipwrecks, and the anchorage of Dor (Kingsley and Raveh, 1996: 55, pl. 49) in the Mediterranean.

Although superficially similar, there are differences between individual rings from Myos Hormos. The most obvious is the large difference in size from ring to ring, ranging across both materials from 37 to 95 mm in diameter. Even in the small sample illustrated here it is possible to see the differences in both size and cross-section, ranging from almost circular (wo482), to oval (wo584), to square or rectangular (wo258). The majority of the brail-rings are pierced with two holes directly through the body of the ring, although some have a single hole. These holes would have provided the point at which the brail-ring was attached to its sail, as evidenced by the example still attached to a fragment of sailcloth, discussed below.

Sail fragments

The 2003 field-season saw the excavation of a small fragment of Roman sail, dating to the late-1st or early-2nd century AD. It was possible to distinguish the sail fragment from other pieces of textile found at the site because of the remains of a wooden brail-ring still attached to it. Sewn to the sailcloth was a reinforcing strip of heavier material, and it was to this that the brail-ring was attached. The ring measured 50 mm in diameter and its orientation (assumed to be with the holes uppermost) confirmed that the reinforcement strip ran horizontally across the face of the sail. Discovery of this fragment (T331) (Fig. 5) also enabled the identification of other pieces of reinforcement

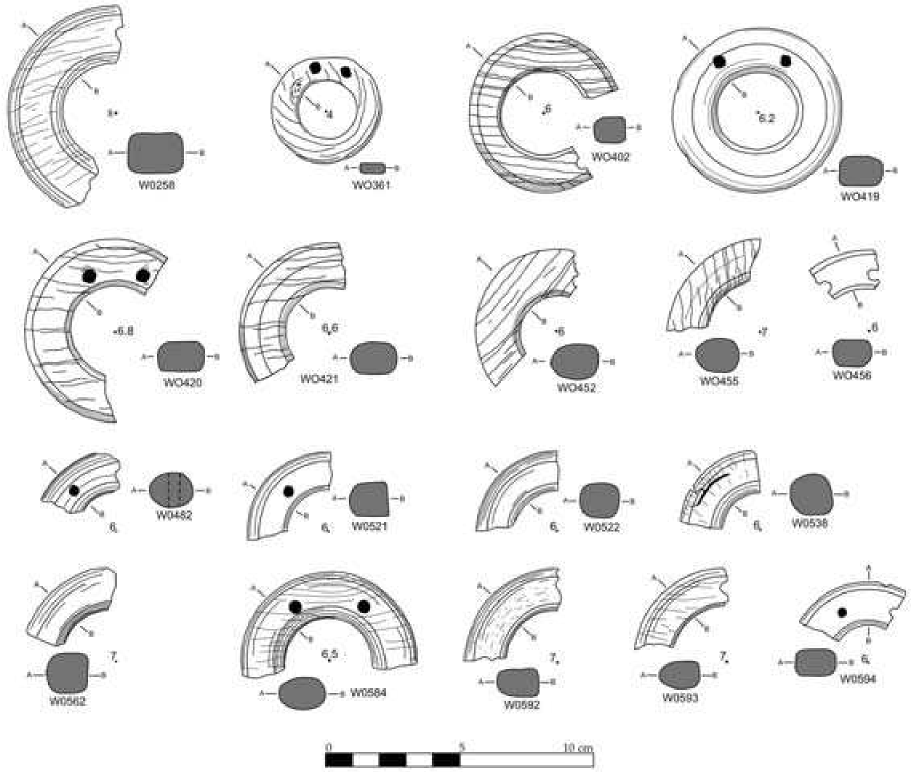

Figure 4. Examples of wooden brail-rings from Myos Hormos. (J. Whitewright)

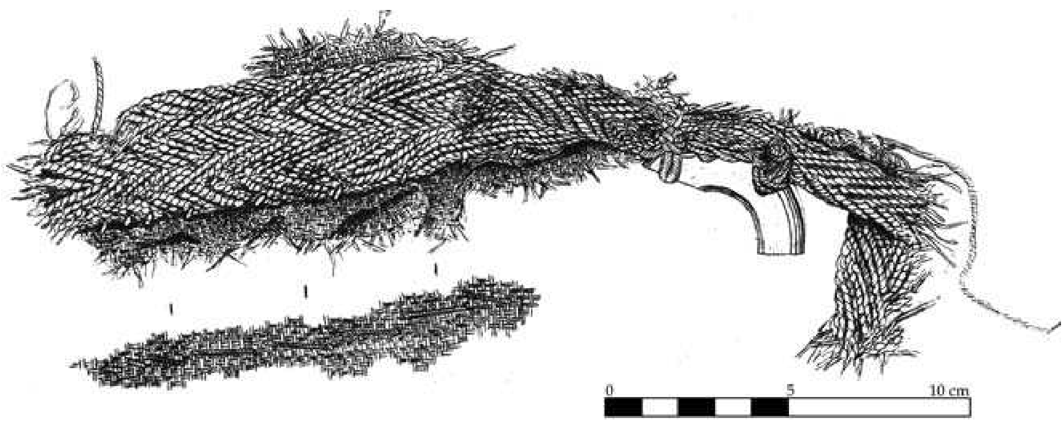

Figure 5. Roman sail and brail-ring from Myos Hormos. (J. Whitewright)

webbing and fragments of sail. One of these strips (T27) measured 1.32 m long; the brail-rings were no longer in place but remains of the twine used to attach them were. Two sets of attachments were found, spaced 810 mm apart, and these corresponded to the holes on the brail-ring still attached to the fragment of sail (T331). The webbing strip (T27) also runs along the length of a seam joining two different pieces of cotton sail together (Handley, 2003: 57). In total 69 textile fragments which probably had a maritime use were recovered during the excavation; 61 were pieces of webbing strip and four were definite sail fragments (pers. comm. Handley). Remains of sails are particularly rare in the archaeological record: comparable ancient examples come from Edfu (Rougé, 1987) on the Nile and the Red Sea port of Berenike (Wild and Wild, 2001), discussed below.

Discussion

The archaeological remains of the rigging of vessels using the port of Myos Hormos during the Roman period fall within the same tradition as other published finds from the Mediterranean. The general form of the deadeye, sheaves, brail-rings and sailcloth is consistent with finds from classical contexts within the Mediterranean basin and comprises most of the components required to rig a sailing vessel within the classical Mediterranean tradition (Whitewright, in press b). Brails and brail-rings are a component unique to the Mediterranean sailing rig. Their use is inconsistent with any of the other sailing rigs known to have been used at this time in the Mediterranean or Indian Ocean. As a result of this, is seems reasonable to assume that Roman sailing vessels engaged in trade in the Indian Ocean were outwardly similar in appearance, operation, and capability to their Mediterranean contemporaries, at least in terms of their sailing rig. However, detailed comparison with similar finds from the Mediterranean reveals that there are archaeologically-visible differences between rigging elements from the Red Sea and those from the Mediterranean, which are discussed below. The possibility must also remain that the corpus of rigging material from Myos Hormos is also representative of sailing vessels of Indian Ocean origin, albeit rigged in a Mediterranean style. This is also discussed below.

Roman deadeyes

The deadeye excavated at Myos Hormos bears further comparison with deadeyes excavated from the Roman wrecks of Grado and Laurons 2. These two wrecks date to the mid- and late-2nd century respectively and are therefore contemporary with the deadeye from Myos Hormos. Five identifiable deadeyes were recovered from the Grado wreck (Beltrame and Gaddi, 2005: 79) and 14 from the Laurons 2 wreck (Ximénès and Moerman, 1990: 7). Both wrecks are of interest because of the difference in the type of deadeye exhibited within the context of a single sailing rig. Of the five deadeyes from Grado, two are pierced with three large holes to receive shroud rope, while the other three are pierced with two large holes. All five have secondary holes to receive seizing line. (Beltrame and Gaddi, 2005: 79–80). In the Laurons 2 wreck, six deadeyes were pierced with three holes and eight with two holes (Ximénès and Moerman, 1990: 7). All had secondary holes to receive seizing line, some of which remained in place on one example (Ximénès and Moerman, 1990: 7–8, figs 2 and 3). The largest deadeye from Grado was 147 mm long, 92 mm wide and 26 mm thick, while the smallest was 116 × 78 × 20 mm. Although the largest deadeye was a three-holed type, a two-holed type of comparable size was also found (Beltrame and Gaddi, 2005: 79–80). The deadeyes from the Laurons 2 wreck were all of comparable size; 115 × 90 × 30 mm (Ximénès and Moerman, 1990: 8).

The most obvious difference between the Mediterranean deadeyes just described and the example from Myos Hormos is the size and the arrangement of the rope-holes. The Myos Hormos deadeye is 67 mm longer, 52 mm wider and twice as thick than the largest deadeye from Grado, and nearly 100 mm longer, 50 mm wider and nearly twice as thick as the Laurons 2 deadeyes. The Grado vessel has been reconstructed as being some 16.5 m long and 5.9 m wide (Beltrame and Gaddi, 2005: 79) and the Laurons 2 vessel 15 m long and 5 m wide (Gassend *et al.*, 1984: 103). The general similarity in the dimensions of the two vessels is reflected in the similar sizes of the deadeyes used to support the single mast on each vessel. The much larger size of the Myos Hormos deadeye points to the simple conclusion that it was used to rig a much larger vessel than either Grado or Laurons 2. However, it may not be that simple. The Myos Hormos deadeye has three holes set alongside each other in the centre of the block, while the three-holed examples from Grado and Laurons 2 have one hole set above/below the other two (Ximénès & Moerman, 1990: fig. 2; Beltrame and Gaddi, 2005: fig. 1).

The holes in all three examples are actually similar in size (*c*.25 mm). This indicates that although the Myos Hormos deadeye was substantially larger than the examples from Grado and Laurons 2 it would have used the same size of rope between pairs of deadeyes. It may therefore be the case that personal preference, or the availability of materials, allowed the maker of the Myos Hormos deadeye to arrange the three holes alongside one another rather than one above/below the others, rather than a difference in vessel size. It is also worth noting here that the Myos Hormos deadeye lacked the small secondary holes, present on all the Grado and Laurons 2 examples, which were used to secure the outer rope strop. This indicates a difference in the approach used to secure the deadeye to the main shroud rope. The deadeyes from Grado and Laurons 2 were secured by a rope seizing passing through the block as well as around the shroud, while the deadeye from Myos Hormos must have simply been secured by a seizing around the shroud.

The differences in the form of the deadeye from Myos Hormos and comparative examples from Grado and Laurons 2 is significant, especially given that both were designed to fulfil a similar function on contemporary sailing vessels. On the basis of such evidence, the Roman sailing rig should not be viewed in the generic terms derived from reliance on the iconographic and textual sources. A detailed understanding of the rig is required. There may have been significant differences in the rigging traditions prevalent in the Roman world which can only be viewed through the archaeological record because of the 'fine detail' which analysis of such material affords us. It is unlikely that such detail and therefore small technical differences can reliably be inferred from the iconographic or textual record. The example described above highlights the importance of investigating the detail of ancient rigging through the archaeological record in conjunction with other sources.

Brail-rings

The brail-rings excavated at Myos Hormos provide another example of the diversity of rigging material, both within a region and across the wider Roman world. The first point to note is the difference in diameter between the largest (95 mm) and the smallest (37 mm). This possibly reflects some of the relative size differences between the largest and smallest vessels using Myos Hormos. Brail-rings provide direct proportional evidence for the size of brailing-lines used, because a larger brail-ring will carry a larger rope. Larger-diameter rope will logically be used on larger vessels, with larger sails, rather than smaller vessels with smaller sails. The picture may be complicated slightly from the 2nd century AD when it is possible that fully-2-masted ships may have been present in the Erythraean Sea. Such vessels were certainly in use in the Mediterranean at this time (for example Casson, 1995: figs 142 and 169). Southern-Indian coins show vessels rigged with two masts (Elliot, 1885: pl. 1, fig. 38, pl. 2, fig. 45) as does a graffito on a pottery sherd from the Indian port of Alagankulam in Tamil Nadu (Tchernia, 1998; Rajan, 2002: fig. 4b; Sridhar, 2005: 67–73, fig. 7, pl. 23). Although the sail-plan of such vessels is unclear they at least show that ships with two equally-sized masts were in use in this region as well as in the Mediterranean at this time (cf. Deloche, 1996: 243–4; McGrail, 2001: 253–5). Such vessels may have used two smaller sails rather than one great mainsail, providing us with a sample of smaller brail-rings than would otherwise be expected for a vessel of the same size rigged with a single square-sail. Likewise a vessel rigged with an *artemon* would also have produced smaller rings in association with this sail as well as larger rings from the mainsail. The diversity in the size of brail-rings does, despite these limitations, still provide at least an indication as to the potential differences in the sizes of vessels present at Myos Hormos.

This variation in size can be usefully contrasted with the brail-rings from the Kyrenia ship where a total of 171 lead brail-rings were excavated (pers. comm. Swiny). Of these, 131 were similar in form to those from Myos Hormos (with two holes punched through the body of the ring) and measured between 59 and 67 mm in diameter. The remainder, which measured between 65 and 72 mm in diameter, had a rectangular lug on one side where the attachment holes were located. Lead brail-rings found on the Grand-Congloué wreck are also made in two different forms, one type with a lug and one without (Benoit, 1961: 178). Like the brail-rings from the Kyrenia ship the largest number (*c*.80) have a consistent diameter of *c*.80 mm and are made without a lug. These are not pierced with any attachment holes, so the assumption must be that they were simply attached by ties around the body of the ring. The brail-rings manufactured with attachment lugs are larger; between 90 and 120 mm. Further analysis of the brail-rings from the Grand-Congloué site is problematic because they represent at least two shipwrecks mixed together during excavation (see Parker, 1992: 200–201).

There are two points of note here. Firstly, the relatively-close size of the two forms of brail-rings found on the Kyrenia wreck, which in part backs up the observations made regarding the diversity in size of the Myos Hormos brail-rings. The brail-rings from Kyrenia are similar in size because they come from a single vessel which would have required a single size of brail-ring for a single sail, rather than a variety of sizes for a variety of vessels. The group of 80 brail-rings from the Grand Congloué site which are similar in form and diameter, may also be representative of a single vessel. The second point is the two distinct types of brail-ring form (with lugs for the attachment holes, or without) which are exhibited in the finds from the Kyrenia ship, given their similarity in size and deposition within the context of a single wreck-site. The two different forms possibly represent two different approaches to the problem of providing a fair-lead for the brailing-lines on a single ancient sailing vessel. As such they demonstrate that it is possible to encounter different contemporary forms of a single piece of technology, both designed to fulfil the same function within the sailing rig of a single vessel.

The wooden brail-rings from Myos Hormos also show a lack of uniformity in the way they were made, which can be seen mainly in the cross-section (Fig. 4); different makers clearly had individual techniques which resulted in different end results. There seems no reason at present to suggest that any of the various forms would have been superior to any of the others—it may have just been a matter of personal choice. Diversity in cross-section was also present in the lead brail-rings from the Grand-Congloué shipwreck, where three different cross-sections were observed (Benoit, 1961: 178).

The material used in the manufacture of the brail-rings found at Myos Hormos is also significant. Horn rings comprise 70% of the total number excavated. The use of cattle-horn is consistent with local manufacture using a by-product from animals slaughtered for food (pers. comm. Hamilton-Dyer). Alternatively, the horn rings could have been manufactured on the Nile, as a by-product of cattle slaughtered there, before being transported to the coast. Textual evidence excavated from the Eastern Desert records the transport of shipbuilding timber to Myos Hormos from the Nile (Bülow-Jacobsen, 1998: 66), and associated rigging material could easily have been carried along the same route. The horn rings are therefore probably produced locally either at the port or on the Nile.

The remaining excavated brail-rings were all wooden, and are paralleled by Mediterranean finds from the Cavalière and Grand Ribaud D shipwrecks (Charlin *et al.*, 1978: 57–60; Hesnard *et al.*, 1988: 105–26). These sites produced small numbers of brail-rings, making meaningful comparative analysis of diameter (possible with the Myos Hormos, Grand-Congloué and Kyrenia examples) difficult. Furthermore, in the case of the Myos Hormos rings the wood in question is non-Mediterranean in origin. In the samples analysed, all the species used were either Indian or East African in origin (Blue *et al.*, in press; cf. Vermeeren, 1999). This corresponds closely with the known trade-routes of vessels leaving Myos Hormos, which sailed to both India and East Africa (Schoff, 1912; Casson, 1980; Casson, 1989). The evidence derived from the brail-rings paints a picture of vessels being refitted with locally-produced horn brail-rings prior to their voyage, while rings which were subsequently lost or broken were replaced along the route using local materials. The final act was the discarding of these wooden rings following another re-fit on the Red Sea coast. It is this diversity of origin which probably explains the differences in the cross-section of the wooden brail-rings. Different vessels visited many different ports around the Indian Ocean in the course of trade and are likely to have replaced damaged or broken rigging at each one. Differences in wood-source and cross-section simply represent the different locations visited by vessels and the different people engaged in making the brail-rings. It is still impossible to tell whether or not the brail-rings were made in overseas ports and bought by the visiting vessels or made on board by the sailors from wood procured whenever they made landfall.

Sails

The physical evidence for sails in the archaeological record of the ancient world is very limited. Archaeological evidence comes mainly from Egypt and the Red Sea, fragments of sails having also been found at the Roman Red-Sea port of Berenike (Wild and Wild, 2001) and a fragment wrapped around a mummy at Edfu on the Nile (Rougé, 1987; Black, 1996). The sailcloth from Edfu was made from Egyptian-produced linen reinforced with locally-produced flax (Wild and Wild, 2001: 213; Wild, 2002: 13). The use of linen is consistent with the existing evidence, mostly textual, which points to linen being widely used for sails in the ancient Mediterranean (Black and Samuel, 1991: 220). This is in contrast to the sailcloth from Berenike which was made and reinforced from Indian-produced cotton (Wild and Wild, 2001: 211–20). Like those at Berenike, the sailcloth and reinforcement webbing strips excavated at Myos Hormos are also made of Indian-produced cotton (Handley, 2003: 57).

This suggests that much of the Roman fleet engaged in the Indian trade, was, at the very least, fitted out with imported Indian cotton at Myos Hormos and Berenike or repaired upon arrival in India using Indian products (Wild and

Wild, 2001: 217–18). If the importation of Indian cotton into Egypt is accepted then the sail finds from the two Red Sea ports may represent part of the return Indian trade which is usually ignored by commentators, that of the relatively low-value bulk product, in this case cotton. Indian cotton is mentioned in the *Periplus* (41) as being one of the products of the land around the port of Barygaza. This may be a possible origin of the cotton used in the sailcloth found at Myos Hormos and Berenike.

Roman sails are often depicted in the iconographic record with a series of vertical and horizontal lines running across their face. These have been interpreted as light ropes or strips of textile or leather used to reinforce the sailcloth (Casson, 1995: 68–9, 234). The sail fragments from Berenike and Edfu confirm this. The fragments from Berenike were made with cotton reinforcement-strips running both vertically and horizontally (Wild and Wild, 2001: 214). Likewise the sail from Edfu has a brail-ring attached to the horizontal strip at the point of intersection with the vertical one (Black, 1996: figs 5 and 6). One sail-fragment from Myos Hormos (T392) represents the edge of a fragment of sail including the remains of the webbing strip running away from the edge of the sail. The remains of the brail-ring attachment is present, its alignment indicating that the webbing strip ran vertically up the face of the sail. The surviving edge is probably the head of the sail. In contrast to this the sail fragment T331 (Fig. 5) shows no sign of a vertical webbing strip at the point of attachment of the brail-ring to a horizontal webbing strip. A third piece of webbing and sailcloth (T27) has two brail-ring attachment points which indicate that the webbing ran in a vertical direction. No evidence for horizontal webbing is present at either brail-ring attachment point.

This would seem to indicate that there were at least three possible approaches to sail-making in use amongst the shipping engaged in trade between the Mediterranean and India. One, the approach identified from iconography and confirmed by finds from Berenike and Edfu, used vertical and horizontal reinforcement webbing strips which intersected across the face of the sail and to which the brail-rings were attached. A second technique, identified at Myos Hormos, used only horizontal webbing strips to reinforce the sail, while a third technique seems to have used only vertical webbing strips. It is possible that as well as reinforcing the sailcloth, the webbing strips also served to reduce the amount of stretch which the sailcloth would have been subject to while under sail. These various sailmaking techniques further illustrate the presence of differing approaches to manufacturing ancient maritime technological items which are intended to fulfil the same function. It also highlights the value of the archaeological record in providing a level of detail about a society's material culture which is difficult to infer from other sources.

Conclusion

The maritime finds from the Roman port of Myos Hormos add a great deal to our detailed knowledge of rigging and sails in the ancient world, and especially in the Red Sea and Indian Ocean region where there is a paucity of archaeological evidence. It is likely that Roman sailing vessels in the Red Sea and Indian Ocean were rigged with the same set of component parts as their Mediterranean counterparts, although these components seem to have been made from materials derived from Egypt and the Indian Ocean, rather than the Mediterranean. These finds may be presenting a picture in which many of the ships engaged in the trade with India were refitted en route using local materials or using low-value bulk materials imported on the return leg of the journey. However there is also the possibility that the rigging elements excavated at Myos Hormos which are of Indian origin are representative of Indian ships rigged in the same fashion as their contemporaries from the Mediterranean (cf. Blue *et al.*, in press).

This possibility is hinted at by a couple of intriguing passages in the *Periplus Maris Erythraei* (PME) which describes vessels from Barygaza on the west coast of India trading with the ports on the south coast of the Gulf of Aden (PME 14). Further on, the author of the *Periplus* says of *Eudaemon Arabia* (Aden) that 'because in the early days of the city when the voyage was not yet made from India to Egypt, and when they did not dare to sail from Egypt to the ports across this ocean, but all came together at this place and it received cargoes from both countries' (PME 26 tr. Schoff, 1912). The implication in this passage is that at the time of writing Indian vessels did make the voyage from India to Egypt whereas earlier they did not. It is obvious from reference to texts such as the *Periplus*, along with epigraphic (Salomon, 1991: 731–6) and ceramic (Tomber, 2000: 630) evidence pointing to the presence of Indian merchants in Egypt, that trade in the Indian Ocean consisted of far more than just Roman trade. A series of interconnecting networks of trade and exchange, of varying size and intensity, extended over the Indian Ocean in the early 1st millennium AD. Roman trade with India merely represented a part of one of these networks (cf. De Romanis and Tchernia, 1997; Ray, 2003). It seems very likely that both Roman and Indian Ocean sailing vessels were present in the Red Sea port of Myos Hormos. It is entirely possible that the rigging components constructed from Indian materials may have originated on board Indian ships. Although circumstantial, the archaeological evidence at Myos Hormos may represent the first identifiable appearance of indigenous ancient Indian Ocean shipping in the archaeological record of that region, albeit on its very fringes.

The evidence from Myos Hormos also seems to indicate that the manufacture of rigging material was by no means a uniform trade across the ancient world. The detailed characteristics of a vessel rigged in one location would have been different from a vessel rigged elsewhere. This point is emphasised by the comparison of deadeyes from Myos Hormos and the Grado shipwreck, brail-rings from Myos Hormos and the Kyrenia ship, and also by the contrast in sailmaking techniques in the sailcloth found at Myos Hormos and at Berenike. Such differences may be representative of regional traditions or variations of rigging, operating within an overall Mediterranean tradition.

A growing body of archaeological evidence now means that for the first time it is possible to describe and understand some of the detailed elements of the Roman sailing rig. Previous studies of ancient ships have been exhaustive in terms of the textual and iconographic evidence (for example, Basch, 1987; Casson, 1995). However, the generalised nature of the evidence has tended to result in a homogenous view of the ancient sailing rig. Although this paper has addressed only a small comparative corpus of maritime artefacts it is clear that the detail of the ancient sailing rig is far from uniform. Visible differences in the technological detail of vessels rigged within a Mediterranean tradition have been outlined and discussed. This investigation has highlighted the variation which is present in the maritime technology of the sailing rigs of the ancient Mediterranean. Such differences are often unclear from iconographic or textual evidence because of the problems of ambiguity inherent in these sources. Technology and technological change can only be fully understood and explained via a detailed appreciation of the technology in question (Whitewright, in press a). Only through recourse to the archaeological record can these details, idiosyncrasies and perhaps the impact of the individual on technology become fully apparent.

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