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Stone-shank anchors of the Arab–Indian trade period—were they mooring anchors?

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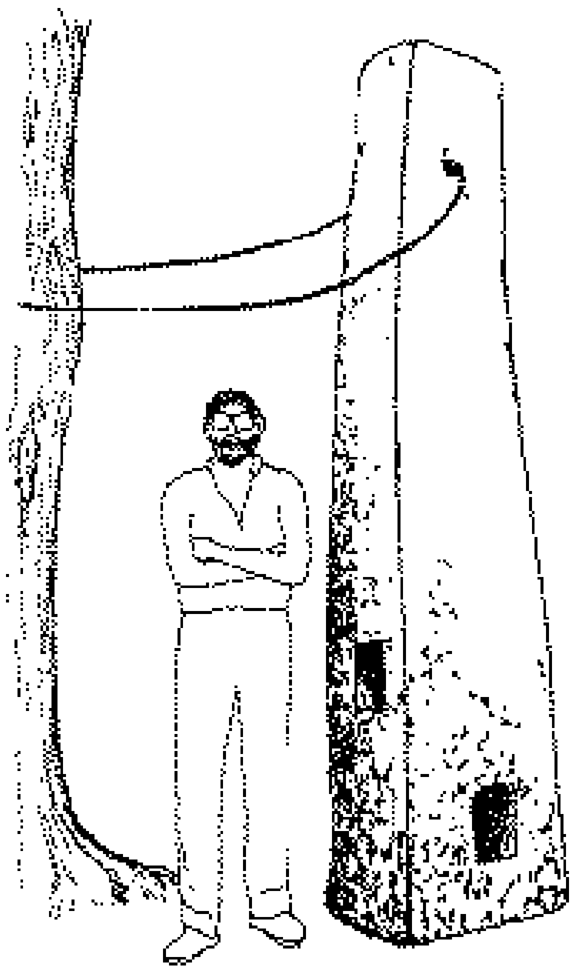


Figure 1. Stone anchor shank from Cursadi Island, Gulf of Mannar, India (sketch based on photograph by Mr Ali Manikfan of Valioor, Tamil Nadu).

From various sites around the western Indian Ocean at least twenty finds of shaped longish stones with three holes are now known. Their cross sections are rectangular and their longitudinal sections slightly trapezoidal. Two rectangular holes in the bigger part are arranged at right angles to each other. The third hole in the narrower end is round and its axis runs parallel to that of the larger rectangular hole near the opposite end (Figs 1–3).

Such a stone from the island of Kilwa, East Africa, though a part of its smaller end is broken off, was rightly recognised fifteen years ago by Honor Frost as the shaft (or shank) of an anchor, which at that time she interpreted as a grapnel because of the transverse holes in the lower part (Frost, 1979: 158).

The finds known to the author are the following.[1] Three fragmentary stone shanks from East Africa, including that identified by Miss Frost, were reported by Neville Chittick (Chittick, 1980). He mentions one more on Slave Island, Aden, and three incomplete examples at Siraf on the Arabian Gulf. Two of these came to light in David Whitehouse's excavations and are dated from context, one to the 8th, the other to the 11th century AD (Whitehouse, 1970: 14 ff., pl.XI ff.).

A group of eleven examples, most of them fragmentary, was found in India during underwater explorations at Dwarka in 1983–84 (Rao, 1990: figs 14 & 34).[2]

In 1987, Professor G.V. Rajamanickam, of Tamil University, Thanjavur, South India, submitted for identification a photograph of, and data for, another particularly large stone anchor shank which is complete and measures 2.95 m in length (Figs 1–2). This had been found in the Gulf of Mannar, off the east side of Cursadi Island, belonging to Tamil Nadu.[3]

In 1991, the author learned by courtesy of Mr Tom Vosmer of the existence of another complete example, the twentieth in this preliminary list. This stone shank was found in the Jama Mosque at Funhilol on Minicoy Island, Laccadives, by Mr Ali Manikfan, Vallioor, Tamil Nadu, who kindly reported it, supplied copies of three photographs and communicated its dimensions.

The submitted pictures and data of these last stone shanks enabled the author to produce schematic scale drawings of them (Figs 2–3). Although not showing the details, they convey a clear idea of these Arab–Indian stone anchor shanks, confirming what one could have gathered from previously published illustrations of other examples. However, one feature is now evident: the cross sections of these stone shanks are not square, as photographs of them and Miss Frost's first drawing might have suggested (Frost, 1979: fig. 5a; 1986: 520, fig. 6a), but rectangular. As such, they correspond to the cross-sections of improved examples of wooden shanks of Greek and Roman two-armed stock anchors provided with a stone of lead, or of wood and lead (Kapitän, 1984: fig. 4 Nos 3c & d & 4).

Anchor shanks with rectangular cross sections cannot belong to grapnels. Shafts of four-armed grapnels are square or round. Moreover, stone as material and the longish forms make it evident that the stone shanks are not the shafts of the rather short grapnels which are shown hanging under the bows of Arab-Indian sewn-plank ships, in the pictures which illustrate the Arab manuscript known as the Maqamat of al-Hariri. There, all parts of the grapnels are uniformly represented in grey colour, suggesting that they are entirely made of iron, as observed by Hourani who writes: 'The Hariri ship appears to have a metal anchor of grapnel shape' (Hourani, 1951: 99; colour reproductions in Ettinghausen, 1977, and Casson, 1964: fig. 185; cf. Chittick, 1980: 74 ff.). Another feature of

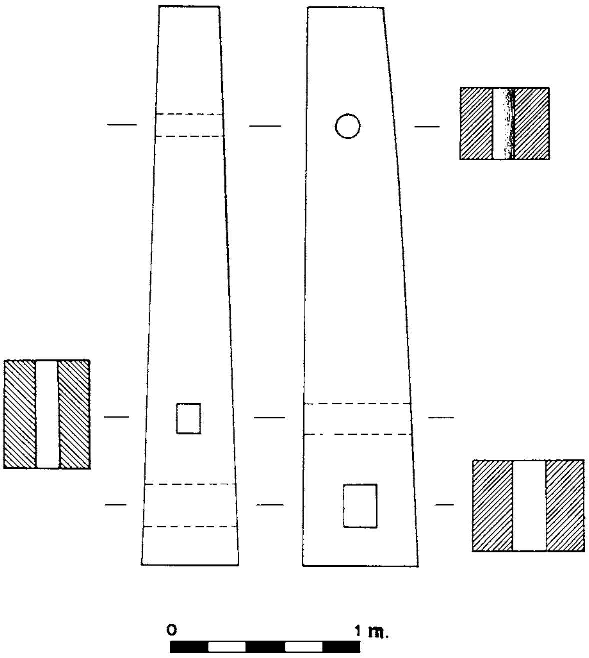


Figure 2. Stone anchor shank from Cursadi Island, Gulf of Mannar, India (see Fig. 1).

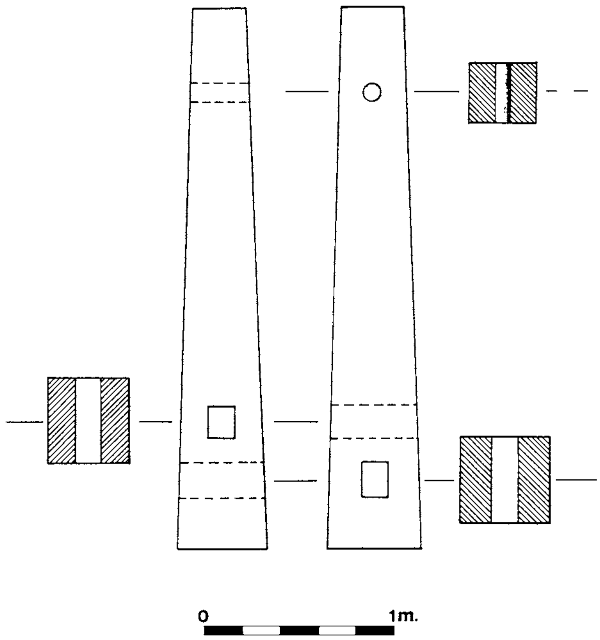


Figure 3. Stone shank found in the Jama Mosque at Funhilol, Minicoy Island, Laccadives by Mr Ali Manikfan.

the stone shanks which speaks against grapnels is the great difference in the size of the two rectangular holes in the lower shank end. The example on Slave Island, Aden, is reported to have one cylindrical hole in the wider end (Chittick, 1980: 73).

These features and the rectangular cross sections of the stone shanks can be explained, however, by assuming we are dealing with a somewhat unusual form of anchor, in which the bigger hole near the broader shank end held an anchor stock, and the smaller rectangular hole held a timber which provided gripping arms projecting in opposite directions (Fig. 4B). The small round hole in the thinner part of the shank likewise held a stock timber, in this case one to which was fastened the anchor rope. The rope could theoretically have been affixed directly to the round hole, but the following points speak clearly for a second stock timber:

1. Another similar stone anchor shank (Fig. 5) which was found in the Red Sea at Lone Mushroom, west of Ras Muhammed (Raban, 1990: 302 ff., fig. 4) likewise has rectangular cross sections and trapezoidal longitudinal sections, but besides the round hole in the thinner part only one rectangular hole in the opposite end, and this passes at right angles to the axis of the round hole. The rectangular hole would have held an arm timber, while the round hole must have held a stock. Otherwise this anchor when cast would not have settled into one of both its gripping positions.
2. The stone shank from Kilwa has been compared by Honor Frost with an elongated late Egyptian stone anchor dating to Roman Imperial times (Frost, 1979: 158, fig. 5). This stone anchor, like other examples of this type, has a rather large transverse rectangular hole in its upper part. There is no doubt that it has been made rectangular to hold a stock, since a small round hole would have sufficed to lash the rope directly to the stone anchor. Two triangular stone anchors from Dorset, which are as yet undated, also have each a quite large transverse hole in the upper end suitable for a more or less angular stock timber (Markey, 1991).
3. The proposed reconstruction of the Arab-Indian stone shanks as double-stocked, two-armed anchors (Fig. 4B) is comparable with six killick-type mooring anchors (Figs 6–7). These were recorded in the south of Sri Lanka, at Kathaluwa-Ahangama, Galle District, where they are used for securing large baskets with live bait of small fish. The baskets are kept afloat, some hundred metres offshore, by means of two big bamboo sticks fastened to their sides below the basket rim.

Each mooring killick consists of a large heavy stone which is almost ovoid, but has two slightly flattened sides. Three timbers are lashed onto the broader end of the stone; two form slightly pointed anchor arms, and the third, a rectangular board, serves as a stock and is additionally fixed by means of indentations beneath the arm timbers. A second stock having a round cross section is fastened onto the opposite tip of the stone. To this stock is lashed, in movable fashion, a strong loop for the attachment of the anchor rope.[4] The four timbers forming the double arms and two anchor stocks are strongly fastened to each other by means of coconut-fibre cords and are also secured by six flexible lilac sticks which embrace the anchor stone parallel to the cord lashings.[5]

At Kathaluwa-Ahangama each killick serves to secure one bait basket. At first this is lashed outboard at the *bala-oruwa* outrigger canoe, when this takes to sea for offshore line-on-rod fishing for tuna. After return the bait basket is left on the sea in the way described above, when a useful quantity of living bait remained.

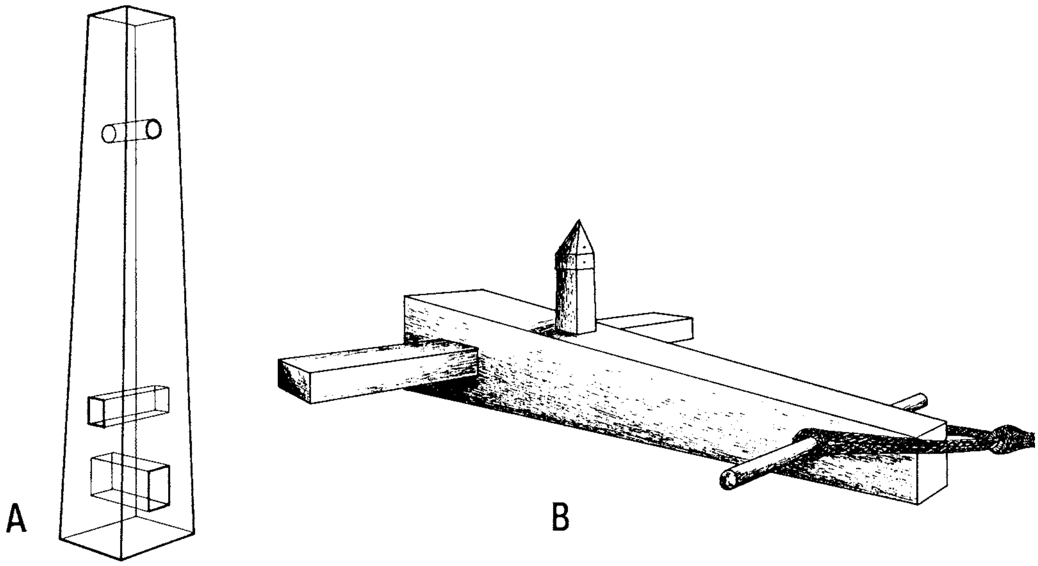


Figure 4. A. View of a stone anchor shank drawn to show the orientation of the holes. B. Proposed reconstruction of the Arab–Indian stone shank as a double-stocked, two armed anchor in anchoring position.

On the south coast of Sri Lanka influence from the Arab-Indian trade period can still be noticed in other nautical equipment, for instance in the rigging of *oru* outrigger canoes with the Arab-Indian lateen or lug sail in place of the older double-sprit sail which is still in use on the west coast. The mooring killicks may have been developed as an intended improvement of stone-shank anchors. While only a few stone anchor shanks have survived undamaged, the stones of these killicks do not break.

In an article on the technology of ancient anchors the author's opinion was that stone anchors with three holes were not developed further and

> …the occasional attempt to transform the stone into a sort of anchor shank (Frost, 1979: 158) had to fail since stone is not a suitable material for forming a shank which works as a lever when the anchor is lifted and its gripping arm breaks out of the seabed (Kapitän, 1984: 35).

However, there is now sufficient evidence for the use of stone-shank anchors in the sea. A possible explanation is that they were not so much applied as ships' anchors to be cast from on board, but served as mooring anchors. Mooring anchors can be laid slowly with care from a floating platform using a hoist, and would only rarely be lifted. This employment of stone-shank anchors is suggested at least for the larger examples. These include some very heavy pieces. The one found at Cursadi Island is reported to weigh 1 ton. The calculated weight of the stone shank on Minicoy Island, measuring 2.86 m in length, is about 880 kg. Moreover, in many parts of the western Indian Ocean there were hardly any harbour facilities; the ships had to stay in the open roadstead. Fixed moorings, which saved crews time searching for a suitable anchorage, would have been most useful.

Nowadays, mooring buoys to which tankers fasten their ropes are, as a rule, kept by several heavy mooring anchors laid

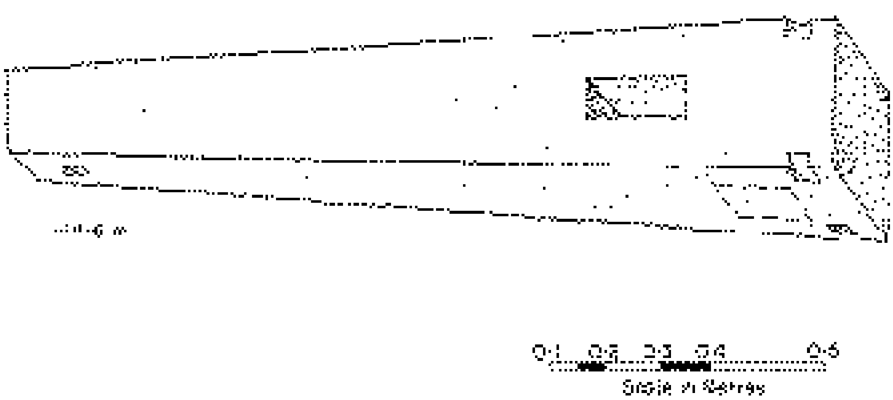


Figure 5. Stone anchor shank from Lone Mushroom, Red Sea, *in situ* (after Raban, 1990: fig.4).

Figure 6a. Double-stocked mooring killick at Kathaluwa-Ahangama, Galle District, Sri Lanka (photo: Kapitän).

Figure 6b. Double-stocked mooring killicks at Kathaluwa-Ahangama, Galle District, Sri Lanka (photo: Kapitän).

out in opposite directions, or the buoy is anchored by means of strong steel posts rammed into the sea-bed. It seems that very little has been written on the history of mooring anchors. A re-examination of the available evidence, including the *in situ* conditions of very heavy ancient anchor elements that were found in the Mediterranean or elsewhere[6], may impart new insights. From the Near East some large Bronze Age stone anchors are known. The sizes of contemporaneous ships cannot be calculated from the weight of such stones, if they served as fixed moorings.

What can be said about the origins of the stone-shank anchors? Miss Frost correctly compared the stone shanks with the elongated type of late Egyptian stone anchors (Frost, 1979: 158), though both belong to two completely different groups. The latter, despite their technical improvement with a wooden stock, are stone anchors, while the former are shank anchors, two-armed and double-stocked. Seeing only these essential differences, however, means ignoring the development. As long as no other more closely related forerunner of the stone-shank anchor is known, the longish late Egyptian stone anchor is likely to be the form from which the stone shanks evolved. This is also conforms with geographical and chronological evidence.

Two closer linking versions are now known: an Egyptian stone anchor with one arm hole only (Nibbi, 1991: figs. 3a, 4, 5; 1993: fig. 7a) (Fig. 8) and, as representative of the stone shanks, the above mentioned example in the Red Sea (Fig. 5). Both have only two holes, though of different shapes. The stock hole of the Egyptian stone anchor is rectangular, while that of the stone shank is round, and the contrary is true of the holes for the arms. The affinity is obvious, but ancient shank anchors in Europe and Asia may likewise have stimulated the design of the Arab-Indian stone-shank anchor.

Notes

1. A list of stone shanks which will include more recent finds from Africa and elsewhere is in preparation by Honor Frost for a re-edition of Hourani, 1951.
2. In Rao's fig. 34 the stone shanks are shown in drawings together with those of twelve stone anchors. The caption states 'scale 1: 35': accordingly, the largest complete stone shank would be only about 1 m long. Probably a large scale drawing was reduced for the purpose of publication and '1: 35' may be only approximate, not allowing one to determine the true dimensions of the stones. However, one recognizes well the rectangular cross-sections of the shanks and the shapes of their holes. It seems that nine stone shanks had lost a more or less large portion of the upper shank end, and in four cases a new upper round hole has been made. The article unfortunately does not include further statements or data referring to these anchor finds.

Figure 8. Late Egyptian stone anchor of elongated shape with one arm hole (after Nibbi, 1991:fig. 3a).

3. Cursadi Island is situated south of the western part and not far from the south-west point of Pamban (or Rameswares) Island (cf. the Sea Chart No.1584 'Trincomalee to Point Alimere'). I am indebted to Mr Ali Manikfan, Vallioor, for having sent me a copy of a detailed map of this area, on which Cursadi Island is shown and named 'Kursadi Tivu'. The shallow waters at its east side are sheltered from northerly winds at the lee side of Pamban Island. Mr Manikfan also kindly contributed a copy of a photograph showing the stone shank from Cursadi Island in an upright position with a person alongside it; from this Figure 1 has been drawn.
4. The movable lashing of the anchor rope has the advantage that it largely avoids entanglements with the anchor.
5. The mooring killicks at Kathaluwa-Ahangama are described by the author in an unpublished typescript (Kapitän, 1991) which in Sri Lanka is preserved in the archives of the National Museum Library in Colombo.

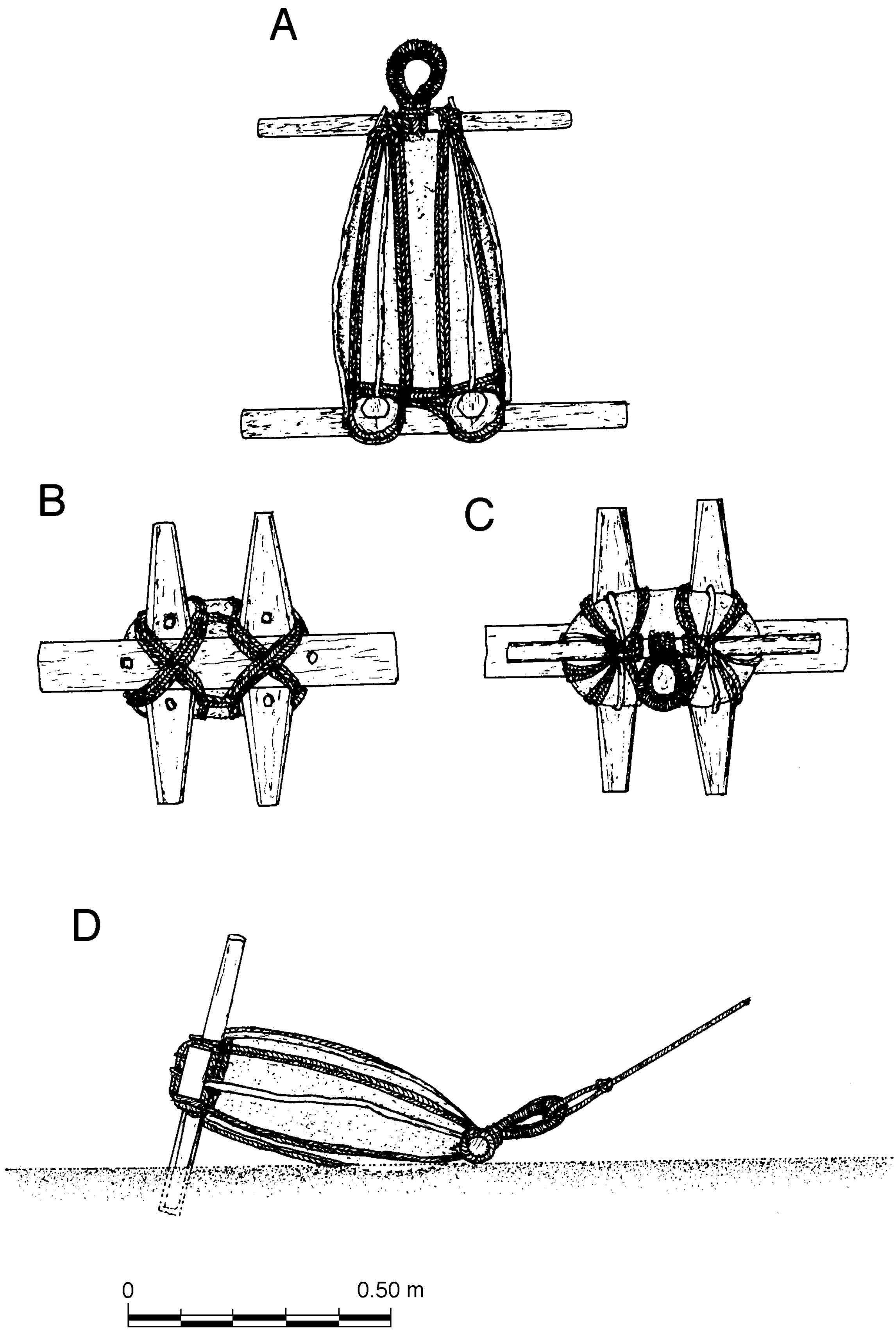
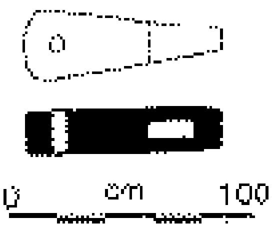


Figure 7. Scale drawing of the mooring killick shown in Figure 6a.



6. Until now the largest is a fixed-type lead anchor stock from Qawra Point, Malta, that had been cast around a big wooden stock (Zammit, 1964: 7, fig. 6). Based on a calculation from the volume of the lead, it weighs about 1850 kg. The whole anchor including its wooden parts may have weighed more than 2 tonnes. Another heavy lead anchor stock weighing approximately 1300 kg was found in the waters of the Peninsula of St Tropez, France (Rochier, 1975). To the large lead stocks, the contexts of which should be re-examined, also belong four finds from the early 1st century BC Roman wreck at Mahdia. Two were salvaged in 1909 and 1911 (Merlin, 1912: 391 ff.) and two in 1948 (Taillez, 1954: 115). Were these really the anchors of this ship, or did they perhaps belong to the cargo? It is true that this wreck has not yet yielded other anchors, but these could have been overlooked, if they consist of iron concretions. The anchoring of one or both the large Imperial pleasure barges of Lake Nemi may well have been by means of a permanent mooring device. The anchor used for it was a 5.6 m long wooden anchor with a lead stock. Parallel to it, but orientated towards the opposite direction, lay a large iron anchor with a wooden sheating around shank and arms (Ucelli, 1950: 234 ff.). Did the latter belong to a previous anchoring or did it confer additional weight?

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Bulletin Australian Institute for Maritime Archaeology, **18**.2: 7–10

Chinese maritime history and nautical archaeology: where have all the ships gone?

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Introduction

Throughout the long relatively land-oriented history of China, one period in particular stands out for its exceptional maritime expansion. Between the Song dynasty (AD 960–127) and the early part of the Ming dynasty (AD 1368–1644), China's imperial will focused its attention overseas. For these hundreds of years prior to the arrival of the Portuguese, China maintained the predominant maritime position throughout the western Pacific and Southeast Asia. The amount of trade that moved through the great ports on the southern coast during the Song dynasty far exceeded anything Europe had experienced. The Yuan (Mongol) dynasty inherited the commercial framework of the Song, adding aggressive military tasks to the evolving imperial navy. The military leadership of the early Ming dynasty brought control of the sea routes to its zenith when Admiral Zheng He organised seven large fleets for journeys to Southeast Asia and across the Indian Ocean. This was the high point of Chinese nautical development, a brief span of three decades immediately before the Ming Ban forced a retreat from maritime involvement.

The fascinating details of this period of Chinese history have been preserved in various official and eyewitness records, but confirmed by very few archaeological investigations. In fact, maritime China as a subject remains understudied for a variety of reasons. (Most history has been written by northern Chinese, not the seafaring communities; most vessels recorded by Europeans after contact represented northern styles, not southern sea-going designs; and, many critical records have been lost.) For western historians and archaeologists with an interest in Asia, however, the Southern Song to early Ming period (or more specifically AD 1100 to 1440) represents a fascinating story, one only slightly understood but filled with questions. UNESCO conferences on topics such as 'China's Maritime Silk Route', and recent discoveries of Song vessels in China and Southeast Asia reflect a new interest in the field of maritime studies. Today, nautical archaeologists are beginning to gain a clearer picture of Asian maritime history before European contact.

This paper will address some aspects of both Chinese commercial trade and the development of the Chinese Imperial Navy from the Southern Song to the early Ming period. Recent developments in Asian nautical archaeology will then be briefly reviewed within this historical background.

Chinese maritime trade in the Western Pacific

Unlike other coastal nations, the Chinese Imperial Government did not always support maritime trade overseas. From the tenth to thirteenth centuries, merchants enjoyed relative support from the State. Later, the early Ming policy attempted to regulate or ban all private trade, securing large monopolies for government profit. The Confucian scorn for commercialism and the low social status of merchants may have influenced this lack of support. The need to control the independent communities of the distant coastal provinces and prevailing attitudes towards contact with non-Chinese also shaped the policy. Smuggling and piracy, always difficult subjects to investigate, have long been associated with China's southeastern coast. Following the Ming Ban, piracy increased from both Japanese and Chinese rebels (Chang Pin-tsun, 1991: 25). Nevertheless, active trade continued in the Western Pacific, and especially Southeast Asia. Encouraged by the Song dynasty, utilized by the Yuan, the privilege of private maritime trade was finally officially banned by the Ming.

Commerce at sea was not new to the Song dynasty. Chinese ships were reported west of Malaysia as early as the fourth century AD (Guy, 1986: 2). By the ninth century, Chinese ceramics appeared as far abroad as Siraf in the Middle East, probably transhipped by Arab merchantmen in Java, Sumatra, or Malaysia. During the Northern Song dynasty, export trade ceramics spread to the Philippines, Indonesia and Thailand in great numbers. This proliferation also probably indicates a large export trade in silk, though archaeological remains of such perishable textiles prove negligible compared to ceramics and lacquer ware.

In the tenth century the Song government began to actively encourage more overseas trade by granting greater fiscal support to the merchant class. The important position of superintendent of maritime trade, established in AD 971, soon came to control all shipping in the great ports of Ningbo, Hangzhou, Quanzhou and Guangzhou (Guy, 1986: 13; see also Clark, 1991). Tariffs on imports added to the imperial treasury. Regulations on ports-of-call and lists of enumerated goods presaged the British Navigation Acts of a much later time period. Travellers such as Marco Polo and Ibn Buttuta both carried accounts of the heights of this commerce back to the West. For example, by the fifteenth century, the average annual amount of pepper imported to China almost equalled the total amount imported into Europe between 1600 and 1650. Pepper was often used to pay the many government employees (Tien Ju-kang, 1981: 187). Hundreds of ships crowded the few harbours open to overseas merchants. These great ports, most notably Quanzhou, came to support large communities of foreign merchants. Remains of ancient mosques and tombs testify to the large Arab population involved in trade on the South China coast. Arab navigators, merchants and explorers were intricately linked to the history of Chinese maritime development.

First-hand accounts from the early Ming dynasty also exist which portray the trading areas in the South China Seas as rich entrepôts for goods of all kinds, and provide detailed itineraries of Zheng He's voyages. The best known of these is Ma Huan's *Ying Yai Sheng Lan (Triumphant tour of the ocean's shores)*, written in 1433 (Ma Huan, 1433 (1970); see also Groeneveldt, 1876). Ma Huan functioned as one of the interpreters on the Ming treasure ships, under the command of Admiral Zheng He. In his work he systematically describes the geography, products, and people of all the countries visited. Fei Xin, a soldier drafted into the fleet from a coastal garrison, also contributed an account. The formal tone of such documents, the long descriptions of trade goods and foreign peoples, reflect the Chinese priority of commerce and Confucian attitude, a seemingly unlikely partnership. The *Ming Shi Lu* (*Ming Dynastic Records*) offers the official version of events and trade relations, along with Zheng He's biography. The voyages directed by the Muslim eunuch admiral from Yunnan represent the climax of Chinese nautical technology.

The Chinese Imperial Navy

Rather than a brief experiment in overseas control, China's medieval navy represented the culmination of a lengthy evolution. By securing the distant sea routes to the south and west, most notably the strategic Straits of Malacca, the military could assure peaceful trade and tributary relations (Duyvendak, 1938). The transcription on a stele erected by Zheng He in 1430 states:

> On arriving in the outlying countries, those among the barbarian kings who were obstructing the transforming influence and were disrespectful were captured alive, and brigands who gave themselves over to violence and plunder were exterminated. Consequently, the sea route was purified and tranquilized and the natives, owing to this, were enabled to quietly pursue their avocations. All this is due to the aid of the goddess [Tien Fei, goddess of travellers and sailors] (Duyvendak, 1938: 345).

The initial foundations of an imperial navy date back to the Song dynasty, during which time ships and men from the commercial trade were gathered for defensive naval operations. The iron and steel industry of the Song provided a firm base, an expansion of industry in some respects exceeding the early industrial revolution in Europe (Hartwell, 1966: 29). China's maritime provinces also offered what Admiral Mahan has termed 'elements of sea power' (Mahan, 1980: 30 ff.), such as natural harbours, timber-clad mountains, and a skilled maritime population already involved in extensive trade (Duyvendak, 1938: 494). By 1237 the Song navy consisted of twenty squadrons and 52 000 men based near the entrance of the Yangtze river. Additional resources could be drawn from a large merchant marine and an endemic maritime population trained in seafaring and naval warfare (Duyvendak, 1938: 491).

The Yuan dynasty continued to support the large permanent navy, taking possession of it almost intact from the Southern Song. The Mongols quickly took command of the foreign ships and crews, and immediately proceeded to enhance naval resources. A large shipbuilding program required an army of 17 000 men to fell trees in the mountains of Jehol (Duyvendak, 1938: 493). (Both diplomatic expeditions and shipbuilding were later referred to as eunuch directed activities.) Yet, unlike the Song's defensive orientation, the navy soon became an instrument of long-range imperial aggression. In 1274 Kublai Khan sent 450 ships and 30 000 Mongol and Korean soldiers to Japan in an unsuccessful invasion attempt. He tried again in 1281 with an even larger force of 150 000 men (Natkiel & Preston, 1986: 36). This time the fleet managed to land forces at Hakata Bay, where they struggled for almost two months against the well-defended Japanese. Both invasions were struck by storms, the *kamikaze* or 'divine wind' from Japanese viewpoint. Anchor stones (called Mongolian anchors in Japan) and other artefacts have been recovered from the remains of the ships in Hakata Bay.

Fleets were also sent to conquer neighbouring Annam and Tonkin (Vietnam). In 1292 a force of 1000 ships and 20 000 troops sailed against Java. The operation featured combined land and sea tactics: half the troops ashore were supported by cavalry, the other half mobile in fast boats (*Yuan Dynastic Histories* Book 210, quoted in Groeneveldt, 1876: 22–3). Kublai Khan also sent a fleet to Ceylon (now Sri Lanka), an important centre for intra-Asian and international trade (de Silva, 1981). Many of these far-flung naval expeditions strained the financial and physical resources of the dynasty, proving less than successful in the end.

These military engagements featured the extensive use of a host of incendiary weapons, from explosive rocket arrows to poison gas grenades. Fire ships, shrapnel bombs delivered by catapult, primitive flame-throwers and crossbows complemented the large numbers of soldiers on each mission. By the fourteenth century, imperial armories forged metals into early cannon, required on board Ming combat vessels. [The military treatise of 1412 describes a cannon of 72 kg, 81 cm long, and with a bore diameter of more than 5.5 cm. The lead shot weighed 1.2 kg (Temple, 1986: 223).] A later military treatise states that each Ming combat vessel, as of 1393, was required to carry four guns with bores 'the size of rice bowls', twenty guns of smaller character, ten bombs, twenty rockets and a thousand round of shot (Schlegel, 1902: 9).

Zhu Yuanzhang, founder of the Ming dynasty, thus inherited a large and growing navy with more than 200 years of experience, featuring specialised tactics, ships, weapons, and trained marines. Effective use of the Ming fleet had decided the outcome of Zhu Yuanzhang's rise to power, as exemplified in the 1363 inland naval campaign at Poyang Lake (Dreyer, 1974: 240). The future emperor refused to close and board with the larger enemy vessels, preferring the use of long-range artillery and fire ships instead. Several other naval engagements also contributed to the Ming victory over powerful rivals.

The imperial navy under Zhu Di (Zhu Yuanzhang's fourth son) achieved the pinnacle of its development about AD 1420, during the midst of the seven diplomatic and trade expeditions to the west. By that time Ming naval forces, consisting of a total of 38 000 ships, probably outclassed those of any other nation (Needham, 1971: 484). Included in that number, approximately 2 700 patrol and combat ships were attached to coastal guard stations or island bases while a main fleet of 400 large warships, along with 400 grain transport freighters, operated out of Nanking. Two hundred and fifty long-distance treasure ships (*baochuan*), built by the imperial shipyards at

Nanking, carried an average complement of 400–600 men each. Three thousand merchantmen stood by as auxiliaries, along with a wide selection of smaller craft for use as launches and dispatch vessels (Needham, 1971: 484).

The treasure ships, or *baochuan*, remain almost a complete mystery to nautical archaeologists. Most of the documentation concerning these ships place their size somewhere about 134 m long by 55 m wide (440 x 180 ft). Estimates of displacement (encountered through a maze of different measuring units) agree with these large proportions. Taking into account the extreme stern overhangs, obscure translations of critical measurements, and the notable lack of technical construction data, a conservative western estimation still places these ships at 70 m long by 20 m wide (230 x 65 ft), with a draft of some 6 m (20 ft), formidable nonetheless (Barker, 1989: 274). Two generations after the Ming Ban had taken effect, officials at the imperial shipyard could no longer remember the construction techniques to build anything on such a scale. A speculative model of what these galleons once looked like is housed at the Zheng He research institute in Nanjing.

The fleets that participated in the diplomatic missions across the Indian Ocean represented only a small part of the total Ming naval force. Many vessels were employed in the suppression of piracy along China's long eastern coast. The imperial navy, over the course of centuries, had grown from a defensive arm into an instrument of aggression and political domination, operating throughout the East China and South China Seas and across the Indian Ocean (Jung-pang Lo, n.d.: 503). (In this interpretation, China possessed the first truly inter-Asian naval squadron.) This would all come to an end in an extraordinarily short span of time. The combined financial stresses of an extended empire, Confucian animosity towards the eunuch class (the Ming expeditions were directed by eunuchs), the completion of the Grand Canal and the continuing threat of invaders from the North all drew attention away from further overseas expansion. Private merchants and shipwrights fled China's maritime provinces and the harsh punishments for engaging in international trade. Many established themselves in the overseas Chinese communities throughout Southeast Asia. [The early Ming period represents an official beginning of Chinese emigration overseas (Chang Pin-tsun, 1991: 13; Wang Gungwu, 1991).] Details of ship construction are said to be visible in the Chinese temples in Indonesia (de Graaf & Pigeaud, 1984: 29). Legends of the Chinese voyages, Tien Fei (the patron goddess of Chinese sailors), and Zheng He himself (known as *Sam Po*, a cultural hero) continue to circulate in these regions. In 1986 China celebrated the 580th anniversary of Zeng He's voyages.

Construction features of Chinese ocean-going ships

Both the long-range naval vessels and the large overseas trading ships employed by the Chinese had one requirement in common: they all had to prove seaworthy in open-ocean environments. Technical information on Chinese ocean-going ship construction is extremely rare. Most of the construction details known today come from the limited sample of the few Song dynasty Chinese shipwrecks as yet discovered (Green, *et al*., 1987).

The Quanzhou ship in Fujian Province, discovered in 1973, is the premier example of Song dynasty merchant ship construction (Green, 1983). The remains lay under two metres of beach silt near Fa-shih village, close to the port of Quanzhou. A solid pine keel and V-shaped hull define the ship's ocean-going abilities. The hull itself consists of a combined clinker-carvel strake pattern, each plank held in place by iron fasteners. Twelve solid interior bulkheads add rigidity and protection from accidental flooding. Stiffeners, also called iron harness spikes (L-shaped brackets) secured the edges of the bulkheads to the hull. Fore and mainmast steps lie directly on the keel. *Chunam*, a substance made from t'ung oil putty, lime and fibres sealed the seams between planks and also covered the iron fasteners, protecting them from salt water corrosion (Li Guo-Qing, 1989). The displacement of the vessel was approximately 375 tons; overall length has been estimated at 35 metres, with a beam of 10 metres (Restoration Group, 1977). Dated coins place the wreck site at about AD 1277.

The Quanzhou site represents the most thorough study of this type. Several important articles have been published in related Chinese, Australian and English journals. It is possible that the vessel belonged to the fleet of Pu Shoukeng, the trade superintendent of Quanzhou at the time. Turning this ships over to the Mongols instead of aiding the desperate Song court proved to be fatal to the old dynasty (Jung-pan Lo, 1969). The Quanzhou ship is probably similar to some of the vessels involved in Khubilai Khan's invasions of Japan.

In Korea, the important discovery of the Chinese trade ship at Sinan in 1975 initiated a program of study and excavation which lasted six years (Green, 1983; see also Green & Kim, 1989). Several features of the Sinan ship are similar to the Quanzhou wreck. Solid bulkheads are connected to a V-shaped hull by numerous stiffeners. Iron fasteners pierce the hull planks. Multiple masts are stepped directly to the keel. A cargo tag included in the artefact collection dates the wreck to AD 1323. The amount of cargo, its good state of preservation, and the successful excavation in the face of extremely difficult environmental conditions highlight the long Sinan ship project.

Besides the large collection of ceramics, the Korean site included over 28 tons of Chinese coins. This reflects the historic economic conditions of a serious trade deficit. The desire for foreign goods led to the massive exportation of coins abroad, specie flight. The previous Song dynasty attempted to control this loss of cash with varying levels of success. No less than ten separate edicts between 1160 and 1265 specified the prohibited exportation of Chinese coin overseas (Green, 1983: 14).

Several other Song dynasty wrecks have been located in Southern China since 1986. In Guangdong province a joint British/Chinese salvage company, while looking for modern wrecks in 1988, came across a Song dynasty vessel. No other information is available as yet. In Fujian Province, near Dinghai Village, three possible sites were located, one yielding Song dynasty ceramic wares. No structure has been revealed yet (Clark & Zhang Wei, 1990: 239). A smaller Song dynasty vessel was discovered during excavations of a shipyard complex at Ningbo in Northern China. The remains also exhibit solid bulkheads, hull planks connected with iron fasteners (protected by *chunam* putty), and fore and mainmast steps braced against the bulkheads (Shimin, *et al.,* 1991). Two other sites of as yet unknown ancient vessels are currently being investigated in China. Of Zheng He's voyages and the Ming vessels themselves, only a rudder recovered in the 1960s serves to support the large dimensions of these ships.

Conclusions

When China's intense involvement with the sea is juxtaposed with the relatively small amount of nautical archaeology yet accomplished, the obvious conclusion is that much remains to be done in this area. For example, though only a few Song or Yuan dynasty merchant vessels have been discovered, none of the ships known to have been involved with the early Ming fleets have yet been found. Traditional ports in Thailand, Vietnam, Borneo, the Ryukyus, Malaysia, Sumatra and Java all served the Southeast Asian and Chinese maritime needs for an extended period of time. Malacca functioned as a virtual overseas naval base for Zheng He's voyages further west. Communities of Chinese were directed to relocate overseas; the tributary nations even received ships as grants from the Chinese empire, for the continuation of peaceful trade. Yet, where is the archaeological evidence of this active period?

Many questions remain to be answered. In the People's Republic of China, work continues at Xiamen University's anthropology department, the Dalian Maritime College, the Quanzhou Museum of Overseas Communications History, and other important centres. Thailand, Malaysia, the Philippines, and Korea all maintain specialised units in underwater archaeology, though under the guise of different names and institutions. Some of the future research must involve zero visibility diving operations in the many riverine sites of ancient ports, a hazardous job not unknown to nautical archaeologists (Van Tilburg, 1994). Further archival work, translation of primary documents and site surveys will help to fill in some of the black holes in China's maritime past, adding not only to the history of the Pacific and Indian Oceans, but to the global maritime story as well.

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Archaeological evidence for fishing in the prehistoric Aegean

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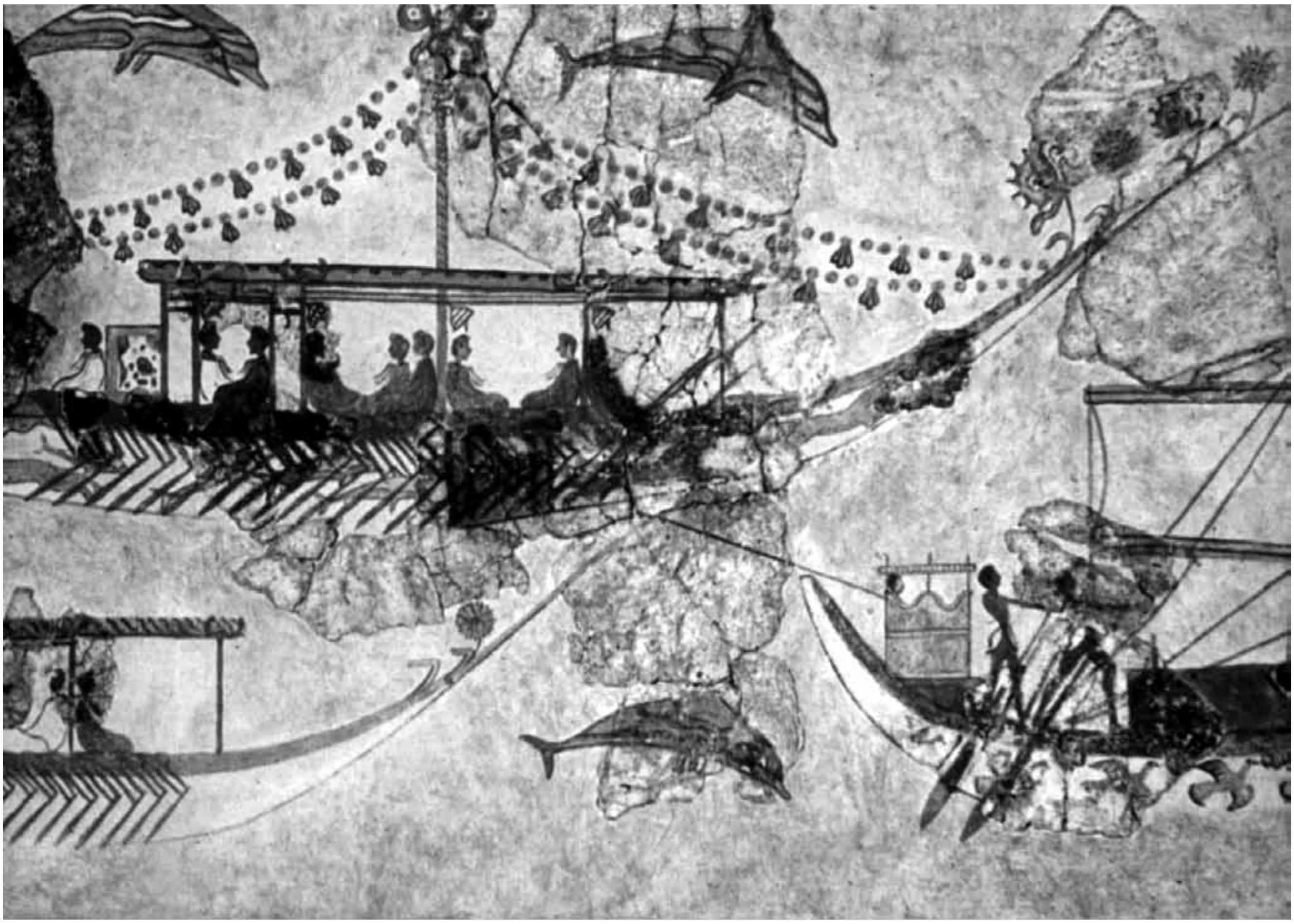

Figure 1. Minature fresco from the West House at Akrotiri, Santorini, Greece.

Introduction

The study of seafaring, of developments in nautical architecture and the study of seaborne trade—all these aspects of maritime archaeology have a long history in classical archaeology. This is hardly surprising, given the fundamental importance of the sea and in particular the role that the sea played as the ancient highway on which people and goods moved. It has been calculated that in Roman times, it was cheaper to ship a cargo of grain from one end of the Mediterranean to the other, than it was to move it by road transport 120 kilometres inland. And during the 1st and 2nd centuries AD, Rome consumed between one quarter and one half a million tonnes of grain a year (Arenson, 1990: 79)!

This great seaborne trade, however, is of greater antiquity. The commodities on which the Bronze Age civilizations were founded—in particular the large quantities of copper required to manufacture bronze—were traded by sea. The most spectacular example of this comes from the well-known excavations of the Late Bronze Age ship which sank off the southern coast of Turkey (at Ulu Burun) some time in the 14 th century BC (Bass *et al.,* 1984, 1989; Bass, 1986,1987; Pulak, 1988). The ship, currently being excavated by Texas A & M University and the Turkish Institute of Marine Archaeology, was carrying a dazzling array of goods, including something like 350 copper ingots, ingots of tin and glass, ivory, ebony, frankincense or myrrh, and pottery from all over the Eastern Mediterranean. Its size can be conjectured by the presence of 24 stone anchors, one of which weighed 300 kilogrammes. The method of construction is identical to that used to build the Roman grain ships over 1500 years later.

Another indication of the sophistication of the Late Bronze Age nautical tradition comes from the slightly earlier site of Akrotiri, on the island of Santorini (Marinatos, 1968–1976; Doumas, 1983). Only one house (the West House) has been excavated in its entirety, and it has been suggested that the owner of this house may well have been a sea captain. Certainly the decoration of the house is principally nautical. The miniature frescoes, for example, show a procession of sailed, and rowed,

Figure 2. 'Frying pan' with spiral decoration and fish.

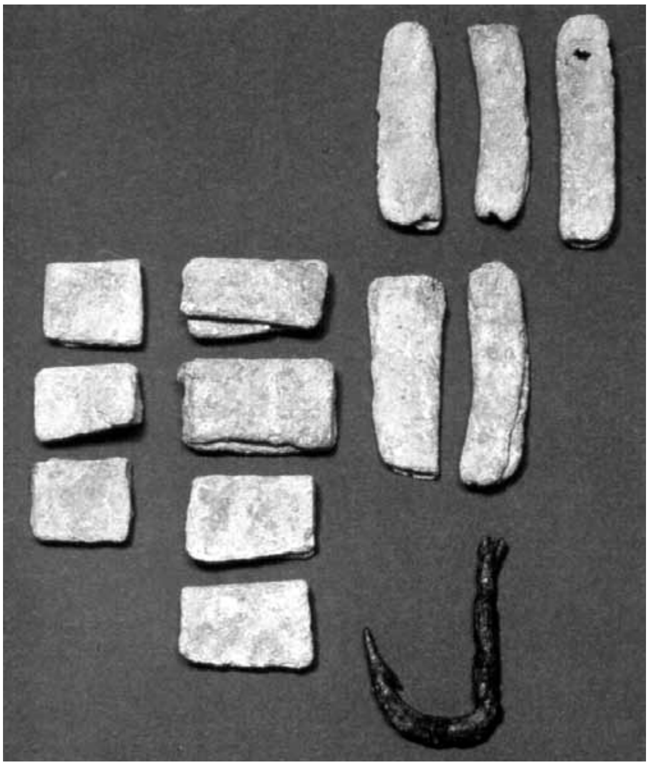

Figure 3. Fish-hook and lead net weights from Perati, Greece.

and paddled ships, of varying size but of great beauty (Fig.1). The frescoes from another room repeat the pattern of the removable 'cabin' seen on the aft deck of the ships.

These two sites—Akrotiri and Ulu Burun—are two of the most significant Bronze Age sites excavated in the last 50 years, and both suggest sophisticated maritime communities founded on a long nautical tradition. It was in the process of investigating the beginnings of this tradition that I came to realise the importance of fishing as a precursor of seafaring and a constant companion.

Chronological developments

Palaeolithic to Neolithic

Our earliest indirect evidence for seafaring in the Aegean comes from the site of Franchthi Cave in the southern Argolid (Jacobsen, 1969, 1973, 1981). The cave was seasonally occupied during the Upper Palaeolithic, and continuously from the Late Palaeolithic through to Neolithic times. During the Upper Palaeolithic, the cave was a long distance from the sea, but sea level rises during the Late Palaolithic period brought the cave and its occupants closer to the sea. The reduction in hunting area associated with this rise in sea level forced the inhabitants to look elsewhere to supplement their food supply and it was to the sea that they looked. Eels, bream, mullet and shellfish are all represented in the archaeological record—in total about 25 fish species have been identified (Rose, 1987). During the succeeding Mesolithic period, the remains of large tuna dominate. Together with these tuna bones are quantities of obsidian. The obsidian can be shown to come from the island of Melos, about 70 nautical miles away, and is therefore our best evidence (albeit indirect) for the beginnings of seafaring. But fishing (initially from the shore) came first, and it seems likely that it was fishing which provided the impetus for the development of boats and widespread sea travel.

Early Bronze Age

Fishing continues to play a significant role during the Early Bronze Age. Our earliest examples of representational art—the so-called 'frying pans'—show boats, and are usually associated with fish (Coleman, 1985) (Fig.2). Most of these objects come from the island of Syros, where some of the earliest bronze fishhooks are found. Fish and marine resources in general become a part of the artisitc repertoire of the period and shells are common in burials (whether as the remains of funerary meals or as grave offerings is unclear).

Middle Bronze Age

A number of developments occur during the Middle Bronze Age, not least of which is the fact that different areas of the Aegean develop at different rates, from the beginnings of palace-based civilizations on Crete to the continuance of farming villages on the mainland. It is not surprising that most of our evidence for maritime activity comes from Crete and the Cyclades.

Boats of various types are represented on seals and as models. Marine motifs continue, but in a greater range of artistic media (seals, pottery, models) and actual shells (painted, lead filled) or copies made in pottery or stone are found in burials or other so-called 'religious' settings. The earliest written scripts (as-yet undisciphered) employ pictures of ships, fish and shells as symbols.

Fish and shellfish were important in other more practical ways. There are good indications that the purple dye industry developed in the Aegean at this time. The dye comes from a liquid in the hypobranchial gland of the shellfish *Murex brandaris*. On exposure to light, this liquid turns purple and unlike other organic dyes it does not fade. Heaps of murex shells have been found at sites on Crete and on the island of Kythera.

Fish remains in pots at Knossos and Kommos on Crete (Rose, in press) indicate that fish were now being preserved in some way, thus providing an important stored food resource. Garum, that famous smelly fish sauce from Roman times was the successor to this early form of fish preservation. We do not know when the manufacture of garum began.

Late Bronze Age

During the Late Bronze Age, evidence for the maritime nature of Aegean life and of the role of fishing specifically continues to mount. Artistic evidence is well known—Marine Style pottery, the famous Octopus stirrup jars, numerous boat models, frescoes with marine themes. Triton shells are copied and appear to have had some symbolic associations. Scores of bronze fish-hooks and for the first time recognizable net weights (in this instance made of folded sheets of lead) come from coastal sites throughout the Aegean (Powell, in press) (Fig.3). That fish were now not just preserved, but were traded, is evidenced by the presence of imported fish at the sites of Kommos on Crete and at Hala Sultan Tekke on Cyprus (David Reese, personal communication). On the Ulu Burun wreck, deposits of fish bones may prove to have been part of the cargo, but the opercula of murex definitely were (Pulak, 1988: 5). Their purpose is as yet unclear. They no-doubt represent a by-product of the purple dye industry but as yet no definite explanation of their possible use has been given.

Fishing methods

Introduction

The importance of the sea and its resources is a constant theme during the prehistoric and Bronze Age periods in the Aegean and, as I have argued in the case of Franchthi, the search for fish was a spur to the development of boats and seafaring. Yet the fishing methods employed in this exploitation of marine resources have never been adequately explored. Although fish remains have specific problems (discussed later), there are a number of sources which allow for tentative reconstructions of fishing methods which could have been employed during the prehsitoric period. As well as the archaeological material (fishing equipment in particular), we have the evidence of iconography, and (with caution) ethnographic writings concerned with traditional Greek artisanal fishing, combined with classical writers of later antiquity.

Reconstructing behaviour such as fishing is a complex issue and it is important to be aware of the pitfalls of ethnographic comparison etc. However, in our favour is the fact that, in general, climatic and physical changes (e.g. salinity levels, sea temperature etc.) have changed relatively little since Neolithic times and aside form the presence of so-called Lessepsian immigrants since the opening of the Suez Canal, there is no indication that the fish species present in Mediterranean waters during prehistoric times are any different from those present today. This means that in our reconstruction of possible fishing techniques, some of the variables (e.g. fish behaviour and the availability of species) are constant. Indeed, many of the descriptions of fish and of fishing which come from classical writers (Aristotle, Oppian etc.) are readily identified today, and evidence suggests that this continuity can be projected back into prehistoric times.

Collecting

At the most basic level, collection of marine resources at the littoral zone is an important addition to the food resources of a coastal community. Our best evidence for this activity will be the remains of animals collected. Calculating the relative importance of such food is difficult—shellfish are likely to be over-represented given the durable nature of their shells, whereas important foods like cephalopods will leave virtually no trace. Only in remarkable instances will the sort of equipment which may have been used for collection survive, generally impressions of baskets such as the example of a wicker basket full of sea urchins from Akrotiri (Marinatos, 1970: 14). The impression was preserved in volcanic ash at the time of the volcanic eruption which destroyed the city around 1600 BC.

Spearing

Spearing extends the range of the hand and can be carried out from the shore or from a boat. At the Neolithic site of Saliagos in the Cyclades, obsidian points were found in large numbers along with the bones of tuna. As no other fishing equipment was found, it was suggested that the fish had been driven ashore and then speared as is common today (Evans & Renfrew, 1968: 79).

Later bronze spearpoints are difficult to identify as fishing, as opposed to hunting, spears, although a two-pronged spear from an Early Minoan burial at Hagios Onouphrios on Crete is generally thought to have been for fishing (Branigan, 1974). A Minoan seal shows a fish, ship and spear (CMS II,1: 287).

Diving

Proof that sponges were used during this period comes from the decorative pattern on some wall plaster at Knossos on Crete, which can be replicated using modern sponges (Evans, 1930: 362). Sponges are also thought to have been used to produce distinctive patterns on a type of pottery called barbotine ware.

Given the depths at which sponges live, divers must have been employed. At a Neolithic coastal site in Israel, human skeletons have been found to exhibit the same distortion of the bones of the inner ear commonly found in professional divers today (Arenson, 1990: 20). No such evidence exists for the Aegean but we can presume that sponges then, as today, were harvested by divers. Oppian (writing in the Roman period) unwittingly describes the depths to which free divers descended when he observes that sponges spit blood (*Halieutica* V, 612–74). He concludes this because many sponge divers, on returing to the surface, have blood on their faces—the result, of course, of nose bleeds due to increased pressure.

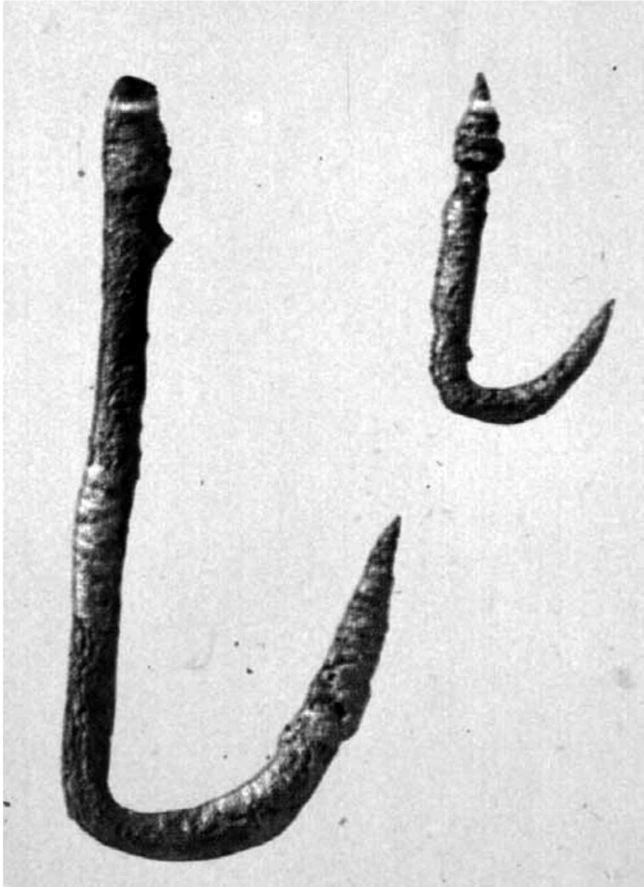

Figure 4. Copper alloy barbless fish-hooks from Syros, possibly used with a lure attached while trolling.

Part of the miniature fresco from Akrotiri may show sponge divers. It is difficult to explain the bag looped around the diver's neck—other than by comparing it to similar bags used by sponge collectors last century.

Traps

Traps were no doubt used to catch a variety of marine species: they are the preferred method for catching octopus, eels and many types of shellfish. Murex have traditionally been caught in pots, often a number of which are strung on a ground line and lowered onto the sea-bed. Because it is important to keep murex alive (if they are dead, the liquid used in purple dye manufacture is discharged and lost), this method is particularly appropriate in that the shellfish can be retrieved alive. A series of Minoan seals which show pots on a line may be an attempt to represent this fishing method. No other good explanation for this illustration has been given, and the site which produced most of these seals was also known to have produced purple dye.

Hooks

Our evidence for line fishing is much more complete than for collecting, spearing, diving, or trapping. Fish-hooks (the earliest of bone, but later of bronze) come from numerous sites throughout the Aegean. Barbed hooks are the most common and vary in length from 2 to 9.5 cms. Barbless hooks with line attached (such as those from Syros Fig. 4) may have been used with a lure attached while trolling. A number of hooks have the remains of line, but unfortunately no analysis has been carried out to date. It would be useful to know what the line was made of, in order to determine such things as breaking strain. It would also be fascinating to compare the ancient knots with those currently in use. Certainly the shape of the prehistoric bronze fish-hooks is familiar and the lack of an eye (most have a splade end, or ridges to facilitate the attachment of line) is common still in Greece. In this respect, the prehistoric Aegean hooks differ markedly from those in use in Egypt (Bates, 1917), which almost always have an eye. The change to an eyeless hook—which occurs in New Kingdom Egypt—is intriguing. Perhaps it is an Aegean innovation adopted by the Egyptians.

A type of fishing which is widespread in Greece today is the long line (or *paragathi*). A series of small lines (with hooks attached) are tied to a longer line which is set at various depths (depending on the fish sought) and later retrieved. The lines are stored in special baskets, so that the hooks can be neatly attached to the rim and the line does not become tangled. At a Middle Bronze Age site on Santorini, about 20 fish-hooks (all of bronze and of identical size) were found, stored with some sort of line, in a pot (C. Televantou, personal communication). It seems very likely that this is the earliest evidence for the use of a long line in the Aegean.

Because the short lines on a *paragathi* may snag, a device which can be lowered down the long line and used to free the snagged line has developed. In Greece it is called a *kouloura* and is shaped like a quoit. Examples of these come from excavations in Israel (Galili, 1993), but as yet, none come from Greece.

Pictures of fishermen are rare, but when they do occur, it seems likely that line fishing is represented. Such pictures include the fisherboys from the West House at Akrotiri (holding a catch of dolphin fish, with heads drawn remarkably accurately given their size—Fig. 5) and a number of Minoan seals.

Nets

Nets are the method with the potential to catch the largest number of fish, yet this is one of the most difficult methods to identify archaeologically. The nets and floats are unlikely to survive, and weights could have been made of wood or other perishable material. If weights are found—and there are numerous weights (of stone) found in most archaeological contexts—it is almost never possible to be precise about their possible use. Indeed many weights were no doubt re-cycled in various contexts. An example of this problem is seen with the discoid terracotta weights commonly found in Late Bronze Age contexts. These are almost always referred to as loomweights and in most instances this is surely correct. However, almost identical weights (also of terracotta) are used in some parts of the world as net weights (Van Effenterre, 1980: 76). Unless the context suggests their use (e.g. some have been found in the sea off the coast of Bulgaria, (Dimitrov, 1979), it is not possible to be definite about such objects.

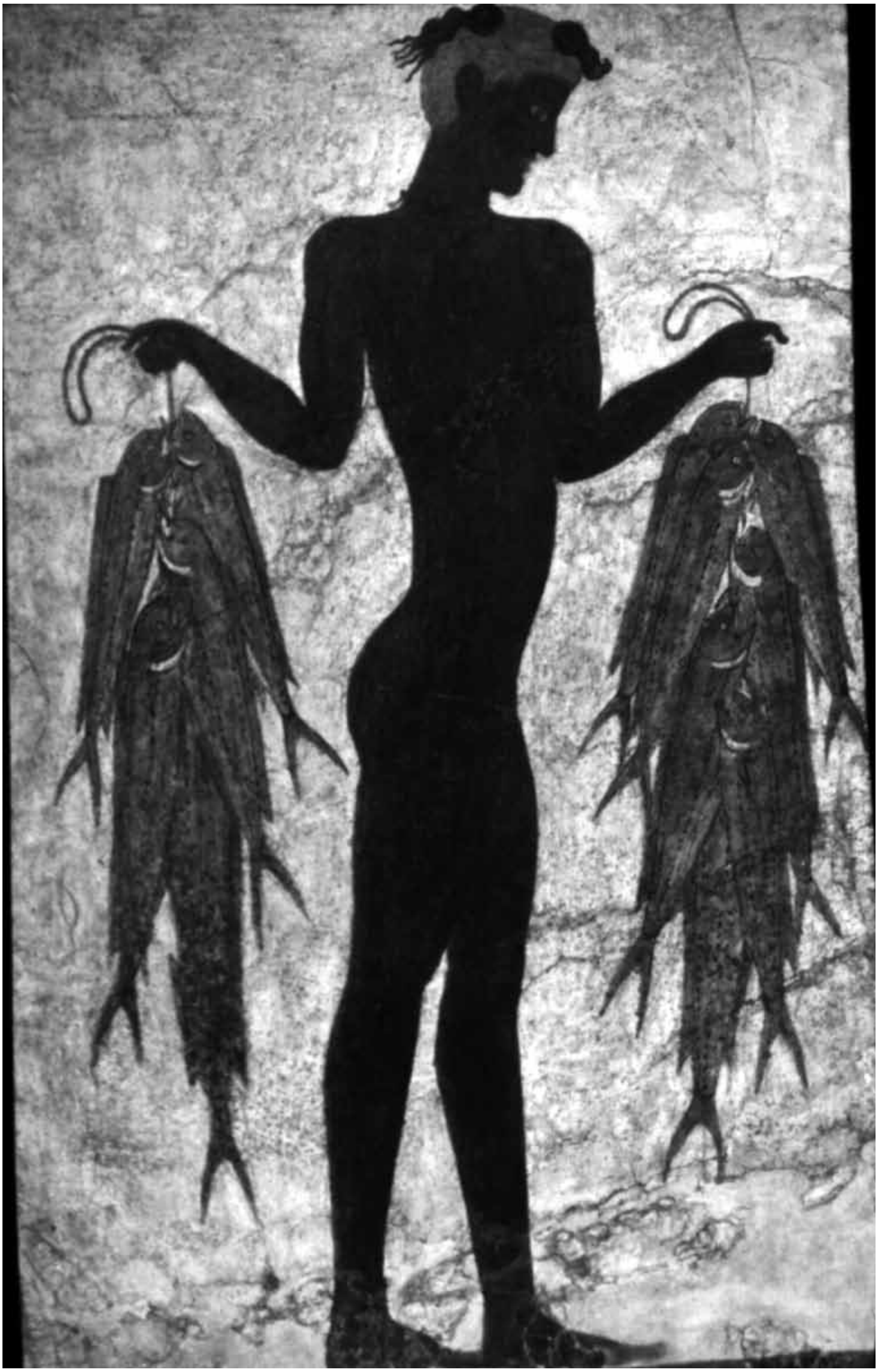

Figure 5. Fresco from the West House, Akrotiri, showing fisherman carrying a catch of dolphin fish.

Folded lead weights, on the other hand, are clearly net weights. They come from a number of Mycenaean burials and at the excavation at Perati (Attica), the workmen identified the weights as similar to those used today on trammel nets (*manomena*) (Iakovides, 1969: 355). A beach seine is illustrated on a Mycenaen pot from Naxos (as yet unpublished: O. Hadjanastasiou, personal communication). The Ulu Burun wreck produced a large number of lead net weights, but the most interesting are 21 found, together with a small lamp, inside a pithos (Pulak, 1988: 5). It sounds like a night fisherman's creel.

Illustrations of net fishing are not common, and seldom can the exact method be deduced.

Conclusions

What can be learned about the role of fishing in this period and what further work can be done?

1. Fishing was practised before the development of boats, but developments in fishing coincide with developments in seafaring. I have little doubt that the connections are not fortuitous, but that fishermen provided the skills necessary for the movement offshore and that the possible returns from fishing were one of the motivations for the investment (in both labour and materials) required for shipping. It is common today for fishermen to join the merchant marine to make money, return home to fish in their retirement—and end up opening a fish taverna! I doubt if this pattern of work has changed much since antiquity.
2. A range of fishing methods was employed and can with some certainty be reconstructed—even if the evidence is circumstantial.
3. Fish and marine life are widely represented in art—and often with remarkable accuracy. This suggests that artists were familiar with the animals and in many cases they appear to have drawn from life.
4. Given this intimate knowledege of the marine world, it is perhaps not surprising that marine organisms were given symbolic value—either assuming some sort of religious significance (shells in sanctuaries etc.) or being adopted in written systems
5. When later trade develops, the indicators of large scale trade (defined by Sherratt, 1991 as the presence of Canaanite amphorae and large stone anchors) are always found at sites which similarly have good evidence for fishing.

Where to now?

The one source of information which I have not discussed is the remains of fish themselves.

There are a number of reasons why fish bone reports for the period (and, in fact, for Greek history generally) are rare. Most excavations conducted during the first half of the twentieth century (and prehistoric Aegean archaeology is only 100 years old) and many since then have ignored faunal and other environmental evidence. To some extent, this reflects a bias in favour of more substantial evidence such as pottery and so on, but also is a product of the sort of excavation methods employed. Faunal remains (and in particular seeds and fish bones) will only ever be retrieved if careful seiving is undertaken. Sebastian Payne's experiments at Sitagroi twenty years ago (Payne, 1975) showed in stark detail the bias inherent in different recovery techniques. For example, 9 species of fish and 14 of bird were identified **only** from water-seived samples. Simple trench recovery, or seiving with large mesh sizes will significantly distort the evidence.

Other factors, however, are not the fault of poor excavation work. Because water provides better support for animals than does air for terrestrial species, fish bone is light and easily fragmented—and although this lightness makes it easy to distinguish fish bone in any bone assemblage, it also means that it is much less likely to survive than the more robust bones of other vertebrates.

As well, within the one fish skeleton, the mechanical properties of the different parts of the skeleton vary—so that, for example, vertebrae may be more likely to survive than other parts of the neurocranium. This is the case with other animals, but the situation is made more complex by the fact that the skeletal elements that are robust in one fish species may not be the same as those that survive in other fish species—and even within the same family, the mechanical properties of the hard tissues may vary. Given that the elements most useful for species identification are not the same for all species of fish, any understanding of the relative importance of different species may be difficult to determine.

Other factors specific to fishing are involved in the process of archaeological deposition. A study of traditional fishing in the Orkneys (Colley, 1986) showed that although fishing was the mainstay of the settlement's economy, the practice of processing the fish away from the settled area meant that very few fish bones were present in domestic contexts. Had this village been the subject of later excavation, there would have been no material evidence for the central role that fishing actually played in the community. Methods of butchery, cooking and consumption may similarly affect the record.

Even when the conditions are right for the preservation of fish bones, and careful excavation has resulted in their retrieval, until recently study was hampered by the lack of adequate reference collections for identification purposes. None existed in Greece prior to my establishment of such a collection at the Fitch Laboratory, British School at Athens, in 1994. The collection is not yet complete, but it does allow for study to be undertaken on a more accurate basis.

What can be learned from a careful study of fish remains?

At one level, a careful study of fish bones will expand our understanding of the way in which early man exploited his marine environment—whether at the littoral zone or in the open sea. It gives us information about diet, fishing methods and catch processing and bones can be analysed to determine season of catch and therefore periods of occupancy. Detailed study should tell us the extent to which marine resources played a critical role in subsistence decisions—and given the paucity of agricultural land in Greece and the nature of the peasant mixed economies that were most common, it is likely this role was substantial. On some islands it may have been crucial.

At another level, fish bones, scales and otoliths can provide important environmental and ecological information—on the past distribution of fish species and the impact of human exploitation. Such information has in the past not generally been acknowledged as one of the duties of archaeology. The data which archaeologists acquire may often be the only evidence upon which fisheries biologists can depend if they are to undertake long-term studies of fishing impact. The presence of particular species may indicate changes in climate or sea conditions and changes in evidence over time can suggest over-fishing. In The Netherlands, for example, it was archaeologists who were able to solve the problem about whether or not the large catfish (*Siluris glanis)* was indigenous to the Netherlands, and whether, therefore, it was in need of protection. Elsewhere in northern Europe, an analysis of sturgeon scutes between the 8th and 12th centuries showed that there was a progressive decline in fish size, perhaps related to the fact that, as only the female sturgeon grows over 2 metres, selective fishing for large specimens would deplete breeding stock (Wheeler & Jones, 1989: 166).

No work of this sort has yet been undertaken in Greece. At the Neolithic cave site of Youra in the Sporades, however, excavations have produced vast quantities of extremely well preserved fish bones, scales and otoliths. As well, 20 bone fish-hooks (the largest such collection found to date) have been discovered, making an analysis of fishing methods possible. The information that could be obtained from the 13 kg of fish bone so far excavated (in just 3 months) is of great significance—not only because the site is on the sea route to Asia Minor and is good evidence for sea travel during the Early Neolithic and earlier, but because it could provide important information about fish stock levels at this time. Given the parlous state of the Mediterranean today, all such information is useful in understanding the process of over-exploitation of resources.

I believe that the connection between fishing and seafaring is indisputable. In the past, like Homer's heroes who ate meat and disdained fish, or like the Roman comic writers for whom fishermen were simply figures of fun—in the past, ancient historians and Aegean prehistorians have dismissed the humble fisherman and have concentrated on the more glamorous aspects of shipping and the exchange of goods.

Yet if we are to understand **all** aspects of man's relationship with the sea—**under** the sea as well as over it—then a study of fishing and its place in antiquity is long overdue.

Acknowledgements

I would like to acknowledge support from the Australian Archaeological Institute at Athens, the British School at Athens, the Fitch Laboratory and the Catling Memorial Bursary Committee. I thank the Director of Excavations at Youra, Dr Adamantios Sampson, for allowing me to discuss this material. My report of the fish bone assemblage will appear in the final site publication.

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Wrecks and marine microbiology: case study from the *Pandora*

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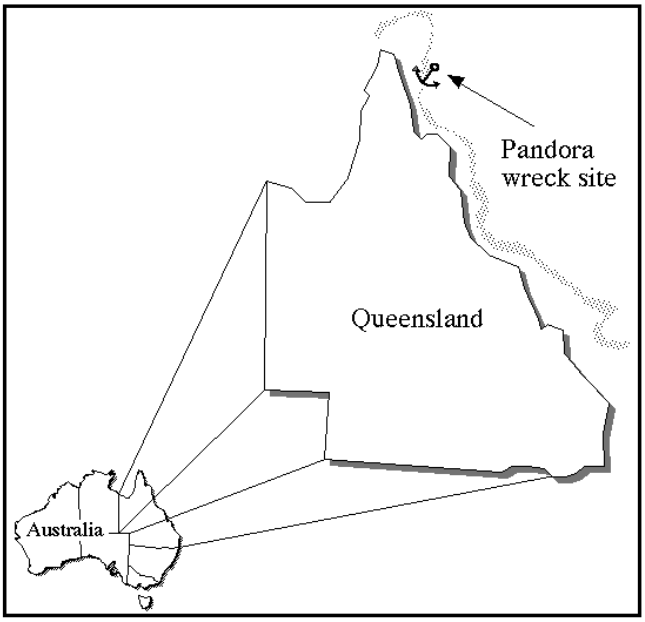

Figure 1. Location of the *Pandora* wreck (latitude 11° 22' South; longitude 143° 59' East).

Abstract

The *Pandora* ran aground on a submerged reef in Pandora Entrance (latitude 11° 22' South; longitude 143° 59' East) and sank in 30 metres of water on 28 August 1791. After lying undisturbed for more than 200 years, the *Pandora* is now the subject of an active archaeological recovery program initiated by the Queensland Museum. The potential of the *Pandora* wreck to function as a research, display and educational resource will be determined. Microorganisms are known to play an active role in the decomposition of timber. Bacteria affect permeability of wood and cause progressive damage to the wood structure. Are microorganisms metabolising the timber hull of the *Pandora* wreck and effectively degrading a cultural resource? In January 1993, the fourth expedition to the *Pandora* included microbiological analyses for the first time. Sampling sites represented the range of disturbances that have occurred over the past 200 years—undisturbed (near and far from the wreck), backfill from two previous expeditions, material dredged on this trip, trench site exposed after dredging, and exposed wreck. Bacterial growth rates (activity) were determined from tritiated thymidine incorporation. Preliminary results indicate that there is increased microbial activity over the wreck compared with a site away from the wreck. Techniques applied to the very coarse coralline sediments have been improved. Data from future *Pandora* expeditions will be compared with those from 1993. The microbiological information will be used to assist in establishing preservation and recovery strategies for timber shipwrecks in marine situations.

Introduction

The mutiny on the *Bounty* is perhaps one of the best known sea stories from the annals of maritime history (Gesner, 1991). Four major films have depicted the epic saga. Equally exciting, however, is the dramatic and tragic story resulting from the British Admiralty's response to the mutiny which led HMS *Pandora* into the Pacific Ocean on what was to be her last voyage.

The *Pandora* was a 24-gun Porcupine class frigate launched on 8 May 1779. She was constructed from oak with the outer hull copper lined. On 7 November 1790, the *Pandora*, under the command of Captain Edward Edwards, departed for Tahiti, arriving on 23 March 1791. The task of Captain Edwards was to bring the *Bounty* mutineers back to England. Fourteen mutineers were imprisoned on board the *Pandora*. On 28 August 1791, the *Pandora* ran aground on a submerged reef in Pandora Entrance on the Great Barrier Reef (Fig. 1) and foundered in a depth of 30 metres. Thirty-one *Pandora* crew and four *Bounty* prisoners perished. On 16 November 1977, divers located the *Pandora* wreck and the site was declared an historic shipwreck under the *Historic Shipwrecks Act 1976* on 25 November 1977. The *Pandora* is one of Australia's best preserved shipwrecks. It is estimated that about one-third of the hull is preserved beneath the sediment.

In October 1983, the first season of major archaeological excavation funded by the Commonwealth Government and organised by the Queensland Museum, began. Subsequently, three further expeditions were carried out in 1984, 1986, and 1993. After these four seasons of major excavation, sufficient information has been gathered to assess the amount of hull and *Pandora* cargo, and crew's personal possessions that has survived.

The decomposition of the timber in the hull of the *Pandora* is considered to be a major historic loss; the anaerobic cellulolytic microbial community would play a cardinal role in this loss. Consequently, in an expedition to the wreck site in January 1993, microbiologists were involved. They were asked to assist in determining whether archaeological retrieval

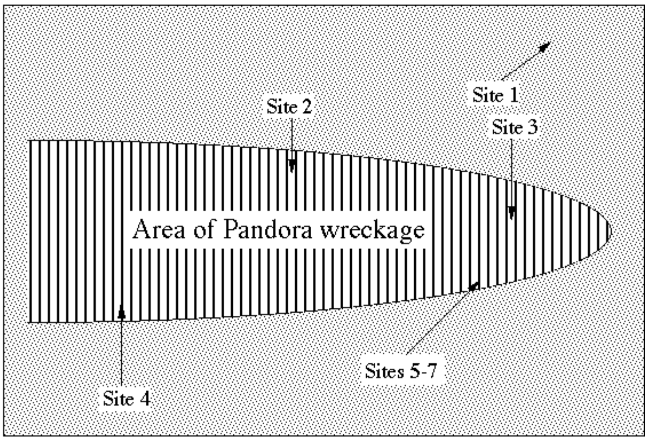

Figure 2. Sediment sampling sites at the *Pandora* wreck. Site 1: undisturbed area away from the wreck; Site 2: undisturbed area over the wreck; Site 3: 1983 backfill; Site 4: 1986 backfill; Site 5: 1993 dredge heap; Site 6: 1993 trench; Site 7: exposed wreck.

of the wreck's contents would adversely affect the condition of the hull remains.

In shallow water environments, sediments are responsible for the recycling of nutrients into the water column influencing productivity and microbiology. Until the last decade, sediment microbiology has been a neglected area of microbial ecology, and even now, is not as well studied as water column microbiology. Coral reefs are less well studied than other sedimentary environments, partly because they are less accessible to microbiologists and because they are generally more complex. Bacteria play a very important role in cycling organic carbon in reef sediments (Pollard & Kogure, 1993a, 1993b). The large grain size, high degree of physical and biological disturbance and high input of organic matter makes it a difficult environment to characterise and study.

To be able to preserve the hull of the *Pandora in situ*, knowledge of the burial environment and the microbial activity surrounding the wreck needs to be obtained. An issue such as this has been addressed in the development of a long-term *in situ* preservation programme of the USS *Arizona* (Oxley, 1992). The deterioration of artefacts can be minimised with knowledge of the biological, chemical, and physical processes occurring in the marine environment. An important technique in the preservation of shipwrecks which does not incur substantial costs is to rebury the material in an environment which mimics the original burial conditions. However, reburial will only be as effective as the knowledge of the preservation conditions (Oxley, 1992).

Bacteria and fungi are the two microbial groups which have been shown to degrade wood. Bacteria tend to cause the majority of microbial degradation of wooden shipwrecks (Ferrari & Adams, 1990). For example, the *Mary Rose* was shown to be degraded by erosion and tunnelling bacteria and to a lesser extent soft-rot fungi. The *Kronan*, an oak ship sunk in the Baltic Sea in 1676, was mostly microbially degraded by erosion bacteria with tunnelling bacteria and soft-rot fungi occurring to a far lesser extent. A Chinese ship wrecked over

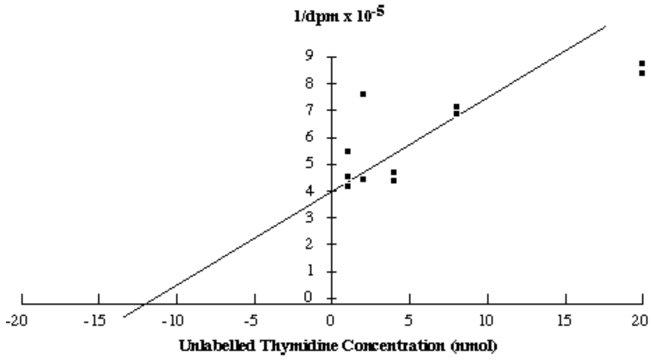

Figure 3. Isotope dilution plot of ^{3}H-Tdr incorporation into DNA for bacteria in sediment surrounding the *Pandora* wreck. Unlabelled thymidine concentration is plotted against the reciprocal of radioactivity incorporated. Negative *x*-intercept is 12 indicating isotope dilution.

700 years ago has also been degraded by bacteria.

Unlike fungi, bacteria can also degrade wood slowly under anaerobic conditions. Benner *et al*. (1984) reported that only 1.5 and 4.5% degradation of wood occurred after 246 days under strict anaerobic conditions. Bacteria are unable to compete with fungi if conditions are favourable for fungal attack, thus extensive bacterial attack will only occur where fungal attack is limited (Blanchette *et al*., 1990). Generally, polysaccharides (hemicellulose and cellulose) are degraded in favour of lignin. It has been suggested that lignin resists bacterial degradative enzymes by acting as a physical barrier (Hedges, 1990).

In many situations, including marine sediments, it is desirable to measure microbial growth rates *in situ*, i.e. directly in their natural environment, to quantify the decomposition rate. Division of the cell represents growth in bacteria. Cell division is related to the measurement of the rate of DNA synthesis (Robarts & Zohary, 1993). Therefore by measuring the rate of DNA synthesis, bacterial growth rates can be determined. It should be noted that DNA synthesis does not occur in non-growing cells, hence only growing cells will be measured.

Thymidine is an ideal precursor for estimating bacterial growth rates as it is almost exclusively used for DNA synthesis and it is not used in the biosynthesis of other macromolecules without first being degraded. Thymidine, in contrast to adenine and other precursors, is immediately incorporated into DNA by thymidine kinase activity and thus it is this step that distinguishes heterotrophic bacterial activity from that of other microbes (Moriarty, 1990). Adenine has been proposed as an alternative precursor, but because of adenine's and ATP's involvement in a large number of biochemical processes in all organisms, results would be far too difficult to interpret (Moriarty, 1990).

The tritiated thymidine incorporation technique is therefore based on the 'principle that there is a direct relationship between the rate of incorporation of thymidine into DNA and bacterial growth' (Moriarty & Pollard, 1990). Two principle biochemical pathways are involved in the synthesis of thymidine nucleotides in the bacterial cell (Pollard & Moriarty, 1984). In the first, the salvage pathway, thymidine

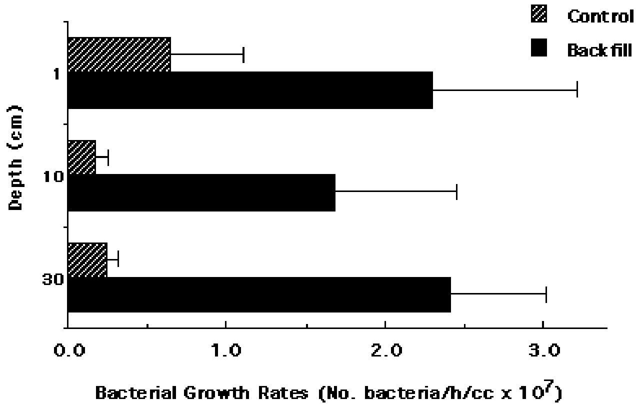

Figure 4. Comparison of bacterial growth rates between Site 1 (control) and Site 4 (1986 backfill). Bacterial growth rates are plotted against the sediment sample depth.

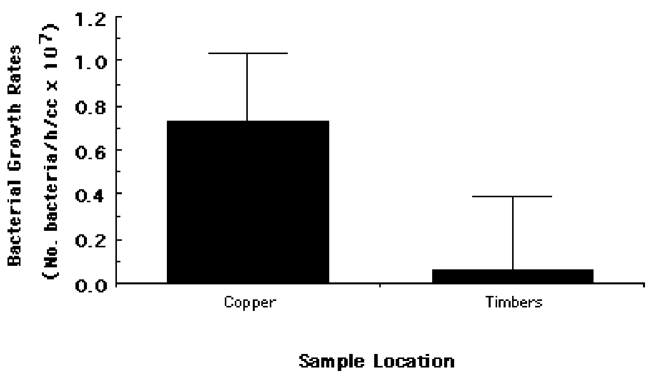

Figure 5. Comparison of bacterial growth rates in Site 7 between the copper lining and the timbers of the hull. Sample position is plotted against bacterial growth rates.

is converted to dTMP (deoxythymidine monophosphate) by thymidine kinase. After further phosphorylation steps, dTMP is converted to dTTP (deoxythymidine triphosphate) and subsequent incorporation into DNA in association with the other three bases occurs by DNA polymerase.

The second is the *de novo* pathway, in which nucleotides are synthesised from precursor molecules, e.g. carbamyl phosphate and aspartic acid. It proceeds via dUMP (deoxyuridine monophosphate) directly to dTMP (Pollard & Moriarty, 1984).

At present, the tritiated thymidine incorporation technique is the most useful technique for estimating bacterial growth rates and thus biomass production in a variety of environments. The microbial ecology of the timber of the *Pandora* shipwreck and marine sediments surrounding the wreck is currently being investigated using thymidine incorporation in an effort to establish this historic vessel as a research, display and educational resource for Australia.

Materials and methods

Sample collection

Coarse coralline sediments were collected from various regions around the *Pandora* wreck site representing the range of disturbances that have occurred in the past 200 years. These regions are depicted in Figure 2. At each site, samples were obtained from a range of depths. All samples, except those at Site 2 were collected by hand using a 100 ml plastic container. Samples at Site 2 were collected using a vibracorer.

Measuring Bacterial Growth with [^{3}H]thymidine Incorporation

[*Methyl*-^{3}H]-thymidine (^{3}H-Tdr) was purchased from ICN Biomedicals, Inc (Costa Mesa, California, USA) at specific activity of 20-40 Ci/mmol (0.74-1.48 tBq/mmol). For all measurements 300 μl of sediment was taken using a cut off 10 ml plastic syringe and added to a 10 ml flat-bottomed polypropylene tube containing 200 μl freshly filter-sterilised sea water, 35 μl ^{3}H-Tdr, and 1 nmol unlabelled thymidine. After 10 minutes at *in situ* temperature the incorporation was stopped by adding cold 10 ml 80% alcohol and 10 mg unlabelled thymidine. Zero-time samples were taken as blanks.

Isotope dilution analysis. Experiments were carried out to check that the rates of incorporation were linear and that no isotope dilution occurred. The isotope dilution experiment was set up as follows. Tubes were set up as for a normal assay but with increasing amounts of unlabelled thymidine (1 nmol, 2 nmol, 4 nmol, 8 nmol, 16 nmol) added to the tubes. Isotope dilution was calculated by plotting inverse dpm against unlabelled thymidine concentration.

Extraction of macromolecules. We chose to use the method as described by Moriarty (1990). After the incorporation was stopped, samples were kept at 4°C. The suspension was then centrifuged at 3 000 x *g* for 20 minutes at room temperature to pellet the sediment. The supernatant was aspirated and discarded and the sediment washed twice more with cold 80% alcohol. After the final wash, 6 ml 20% cold acetic acid was added to the samples to remove interfering calcium carbonate. Samples were kept at 4°C and mixed regularly. The solution was changed after 12 hours and left for a further 6 hours. After centrifugation, the supernatant was discarded and the pellet washed with sodium tetraborate to neutralise the sediment. Sediments were kept frozen and transported back to the laboratory. Two millilitres of cold 5% trichloroacetic acid (TCA) was added and samples heated at 90°C for 30 minutes. The samples were cooled on ice and any remaining sediment particles were removed by centrifugation for 20 minutes at 6 000 x *g* and 4°C. One millilitre of the supernatant was transferred to a glass scintillation vial and 10 ml Ready Safe scintillation cocktail (Beckman Instruments, Fullerton, California, USA) was added. Samples were kept overnight at 4°C to remove chemiluminescence. Radioactivity was counted in a LKB Wallac 1219 Rackbeta liquid scintillation counter (LKB Instruments, Turku, Finland).

Recovery Checks. The efficiency of DNA extraction from the coralline sediments was estimated using a radioactively labelled mixed marine enrichment culture. This was prepared as described by Pollard (1987). 100 ml marine broth (Zobell, 1941) was inoculated with sea water and grown overnight at 28°C. One millilitre of a 4 hour old culture of this enrichment was inoculated into 50 ml fresh marine broth. Growth was monitored spectrophotometrically by following changes in optical density at 540 nm. When the culture was in log phase, 3.5 mCi of ^{3}H-Tdr was added and incubated for 20 minutes. The incubation was stopped by addition of formaldehyde (0.7 ml of 36% v/v) and the suspension centrifuged at 6000 x *g* for 20 minutes. The resulting pellet was washed three times in filter-sterilised milli-Q grade water. A final wash in ethanol was performed. The pellet was resuspended in 700 μl filter-sterilised milli-Q grade water. Fifty microlitres of the cell suspension was washed five times on a 0.2 μm polycarbonate filter with 5% cold TCA. Six replicates were done. These filters were boiled for 30 minutes in 3 ml 5% TCA. The samples were centrifuged at 6000 x *g* for 30 minutes. Half a millilitre of the supernatant was sampled and radioactivity counted. Bacteria naturally occurring in sediment are encased by the sediment material, however, as the recovery culture is a suspension of cells which can be readily washed from the sediment, they were added to the sediment after the alcohol wash in lieu of the label (Moriarty & Pollard, 1990).

Calculations. Bacterial growth rates were calculated from rates of thymidine incorporation into DNA as described by Moriarty(1990).

Statistics. Analysis of variance (ANOVA) was calculated using Microsoft Excel 4.0 and the Tukey's wholly significant difference (WSD) test using Graph Pad InStat on Macintosh computers.

Results

The recovery efficiency of labelled DNA from the coralline sediment was 22%. Isotope dilution occurred (Fig. 3) which was accounted for in the calculations.

In the control (Site 1) site at sediment depths of 1 cm, 10 cm, and 30 cm, the bacterial growth rates were not significantly different. In the 1986 backfill (Site 4) site at sediment depths of 1 cm, 10 cm, and 30 cm, the bacterial growth rates were not significantly different (Fig. 4). However, bacterial growth rates were significantly different between the control site and the backfill site. Therefore, there were no within site differences but there were between site differences.

Insufficient data was available to perform valid post-hoc statistical tests. However, what can be derived from the data is that from the area under the copper sheathing, bacterial growth rates did not seem to be affected (Fig. 5), although biomass was about 3-fold lower (data not shown).

Discussion

To be able to measure bacterial growth rates with confidence in the environment, the following criteria should be met (Moriarty, 1986): (1) the method should be specific for heterotrophic bacteria; (2) the method should not rely on balanced growth; (3) the growth rate should not be altered during the measurement procedure; and (4) if the method requires a conversion factor, it must be able to be accurately determined.

The tritiated thymidine incorporation technique does comply with this criteria but only if certain conditions are met. These conditions are as follows (Moriarty, 1986): (1) the specific radioactivity of the precursor immediately before incorporation into the macromolecule must be known; (2) the radioactivity measured at the end of the experiment must only be in the macromolecule of interest, and (3) the added radiotracer should be incorporated into the macromolecule by only one biosynthetic pathway.

The immediate problem associated with this assay and the study environment is the low recovery of labelled DNA. In other environments, recovery efficiencies have been as high as 81% (Moriarty & Pollard, 1990). In high organic sediment and sandy sediment, 75% recovery efficiencies for DNA have been reported (Findlay *et al*., 1984). Pollard and Kogure (1993a) have used an alternative extraction method for extracting the label from coralline marine sediments. Rather than using an acid treatment which reacts with calcium carbonate and removes any unincorporated label, they used a dialysis method (Pollard, 1987). This dialysis technique therefore appears to be a promising alternative for this environment. In addition, the acid treatment is also detrimental to the DNA resulting in a lower recovery rate of the DNA.

Isotope dilution can occur from both internal and external sources to the bacterial cell (Robarts & Zohary, 1993). The most recognised source is intracellular isotope dilution whereby the synthesis of thymidine in the *de novo* pathway contributes to DNA synthesis. By adding increased concentrations of ^{3}H-Tdr, high enough levels of dTTP will be formed to have an inhibitory effect on the *de novo* pathway (Fig. 6). External or extracellular isotope dilution can be caused by unlabelled thymidine or other compounds competing for the same enzyme as ^{3}H-Tdr during the uptake of exogenous nucleosides into the cell by the salvage pathway (Jeffrey & Paul, 1988) (Fig. 6). It has been reported that ^{3}H-Tdr adsorbs to sediment (Robarts & Zohary, 1993), therefore it is likely that a portion of the added label has been adsorbed to the sediment and thus not enough of the label has been salvaged into the cell. This in turn can result in an insufficient level of dTTP to inhibit the *de novo* pathway thus isotope dilution. This can be overcome in future experiments by adding higher levels of ^{3}H-Tdr to overcome the adsorption or alternatively smaller amounts of sediment.

Increased bacterial activity in the backfill site (Fig. 4) may indicate higher organic material availability. The environment that these bacterial populations are living in is oligotrophic, that is, low in nutrients. The sediment is over 90% calcium carbonate. Therefore, where is the extra organic material in the backfill site coming from? Although it is quite apparent that there is increased bacterial activity at the backfill site, it cannot be assumed that it is a result of the backfilling. The wreck site is a dynamic site. For example, fast currents pass over the site and with them organic material brought and deposited over the site allowing for acceleration of bacterial growth. By dredging the sediment and subsequently backfilling, the sediment and thus detritus material is being disturbed which in turn can fuel the bacterial population activity. On the other hand, it is possible that the bacterial population are obtaining their organic material from the wreck timbers. Is backfilling increasing the timber degradation or is it a phenomenon that is already occurring? Although samples were taken from an undisturbed area over the wreck, the results are unable to be truly compared as sampling at this site was by the use of a

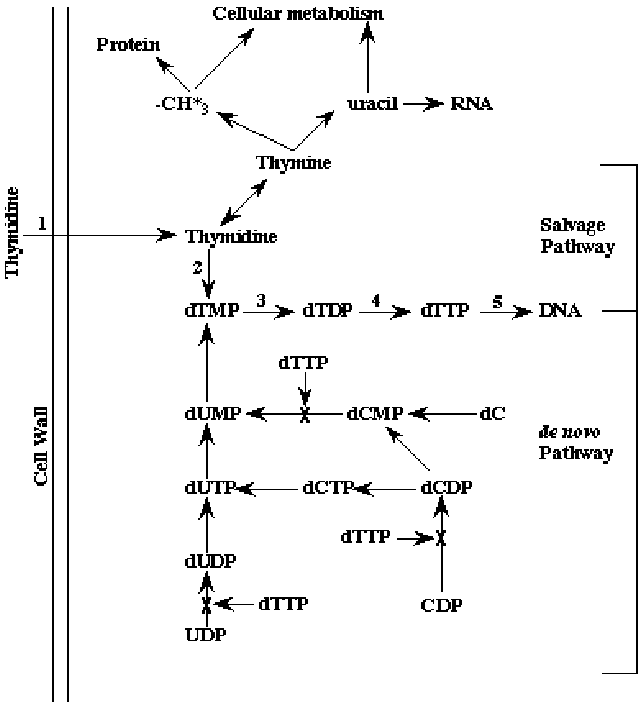

Figure 6. An overview of the biochemistry of thymidine metabolism within the bacterial cell. The ^{3}H label is indicated by an asterix. Sites where feedback inhibition occurs by dTTP are marked with an X. dTMP, dTDP, and dTTP are thymidine mono-, di-, and triphosphates, respectively; dUMP, dUDP, and dUTP are mono-, di-, and triphosphates of deoxyuridine; dC is deoxycytidine; dCMP, dCDP, and dCTP are mono-, di-, and triphosphates of deoxycytidine. Enzymes: 1. active transport mechanism; 2. thymidine kinase; 3. dTMP kinase; 4. nucleoside diphosphate kinase; 5. DNA polymerase. (Adapted from Robarts & Zohary, 1993).

vibracorer and not hand sampled as for the other sites. The vibracorer was not an ideal sampling apparatus as during coring the sediment column was compacted. This allowed disturbance of the bacterial population and hence inaccurate results.

Bacterial growth rates between the wooden timbers were 10-fold lower than the sediment under the copper lining (Fig. 5). This particular area was well protected. There was a high sulphide concentration (unpublished observations) although results have shown that sulphate reduction was extremely slow (unpublished data) which indicates that sulphide is concentrating and not diffusing. Therefore, it can be assumed that nutrients will have difficulties diffusing in and hence the bacterial population may be starved for carbon and as a result may be slowly degrading the timbers.

It is possible that the copper lining may be aiding in inhibiting bacteria hence lower biomass. The copper is not having a completely inhibitory effect as originally thought. Research has shown that copper-based paints can aid in the alleviation of problems associated with the biofouling of wood in the ocean (Austin, 1988).

Overall, at this stage of experimentation it would appear that the bacterial population is adversely affecting the *Pandora*'s timbers at the backfill site. Although initial results do indicate increased bacterial activity around the backfill site, there are many contributing factors to this phenomenon. Since this sampling trip, the tritiated thymidine incorporation technique has been improved for this coarse coralline environment. Thus on future expeditions, data can be compared and a more thorough conclusion will be made as to whether excavation of the *Pandora* is in fact causing rapid decomposition of the hull.

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The *Batavia* Project: an experimental reconstruction of a 17th century East Indiaman

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Figure 1. The replica of the *Batavia* at Lelystad, 1994.

Introduction

Although for many people the building of historic ships is something new, over the centuries people had the desire to visualise their idea about history. Already in the 16th century a classical Roman ship was built. Since the second half of the 19th century a series of ships have been built, ranging from Viking ships to East Indiamen.

Now at the end of the 20th century, historic ships are under construction in several places all over the world . What is new is the introduction of experimental archaeology. Some of these projects are used not only to visiualise the past but also to increase our knowledge about shipbuilding and other related subjects.

In this paper I would like to show one way of using these kinds of projects as a scientific exercise. As an illustration I will use the *Batavia* project in the Netherlands.

In October 1985 the keel was laid for the reconstruction of the 17th century Dutch East Indiaman *Batavia*. Willem Vos, the initiator of this project, had been working for many years on the restoration of old monuments and the building of traditional wooden ships. He started with two major goals: firstly, the reconstruction of the ship would be a way of keeping the traditional craftsmanship alive; and, secondly, it would provide training for young people in the trade of wooden shipbuilding and restoration.

The keel (with a length of 37 m), the stem, the main-frame and the stern were laid and the length (56.6 m.) and the beam (10.5 m.) of the hull were determined (Fig. 2). The hull with the frames and most of the planking was completed at the end of 1988, and a start was then made on the construction of the decks, the masts and other smaller gear and equipment.

In 1994 the construction phase of the *Batavia* was completed. Over nine years the shipyard grew from a sandflat with a keel and a shed, to a complex with several workshops, grouped around the impressive shape of the *Batavia* itself: a woodcarvers workshop where over a 100 sculptures in Dutch renaissance style were made (Fig. 3); a blockmakers workshop in which 400 blocks made from ash, oak and pockwood (lignum vitae) were constructed; a sail loft where 1180 m^2 canvas was sewn by hand; and a workshop where approximately 20 km of hemp ropes were prepared for the complex rigging of the ship (Fig. 4).

The work has been organised around a shipwright assisted, as in the 17th century, by several master carpenters,

Figure 2. The stern section of the *Batavia* in 1986.

Figure 3. The woodcarving shop.

Figure 4. The ropewalk.

and craftsmen who specialise in rigging, sailmaking and woodcarving. These people, at the same time, taught the 50 students who trained on the job.

The project as a whole became an important tourist attraction with 350 000 visitors a year. This touristic success facilitates the financing of the research and shipbuilding.

The preparations and the 'paper-reconstruction'

Starting a project like this is no easy task. The preparations started in 1980 with the research on the construction and other aspects of 17th century East Indiamen. For this research a broad scope of sources is available: written sources, material sources and iconographic sources (Parthesius & Zee, 1991: 9–21).

Because of the richness and diversity of the sources it turned out to be most practical to write a manual for building the ship, in which all the information could be integrated. In this manual we find the main dimensions of the ship, descriptions of certain complicated elements in the construction and a detailed list of specifications of every distinguished part. Since no plans, drawings or designs survived or existed of an early 17th century East Indiaman, we first had to reconstruct the path the 17th century shipwright followed in the preparation of the building after he received his assignment. After we made the decision to build the *Batavia*, our starting-point was the assignment (*charter*) from the board of the VOC to the shipwright on the Amsterdam wharf.

In 1626 the board of the VOC made the decision on the charter of the ships of the largest category. In this charter the main dimensions of the ship were laid down. This assignment contains the following data:

Length between the stem and the stern: 160' (Amsterdam voet =0.285 m) 45.60 m.
The depth in the hold till the first deck: 12 1/2' = 3.56 m
Space between the first and the second deck: 5 1/4' = 1.50 m
The beam: 36' =10.26 m
(Resolutions of the board (*Heren XVII*) 29 Maart 1626, in: Alg. Rijksarchief Den Haag VOC No. 147).

Although for us this list seems to lack sufficient information to build a complete ship, it was nevertheless enough for the Company, and many other customers, to use it as a contract that had to be followed strictly in order to reach the intended result. The shipbuilder even risked penalties if he did not follow the instructions.

In the data of the charter the exact shape of the ship was determined. Seventeenth century Dutch ships were not built using drawings and plans. They were the products of traditional craftsmanship and the skill of adaptation. Every single part of the ship was the outcome of formulae that were based on the

Figure 5. Painting by Rembrandt (1633) of the master shipbuilder Jan Rijcksen (1560–1637), the probable builder of the *Batavia* (photo courtesy of the Royal Collection, Queen's Gallery, Buckingham Palace).

main dimensions. The shipbuilder started the building process by setting up the interpretation of the main dimensions for the specific ship.

First of all, it was this skill that had to be reconstructed. In 1633 Rembrandt painted the Master Shipwright Jan Rijcksen (Fig. 5). At the end of the 16th century Rijcksen was working as a shipbuilder on his own wharf. In the 1620s he was employed by the VOC as director of the wharf (*Heer van de werf*) in Amsterdam (Eegenhen, 1970). In that function he was responsible for the design of the ship and the building organisation. In the daily reports of the Chamber (*Kamer*) Amsterdam, the company was decentralized with branches in six important cities in the Netherlands, we can follow his journeys to the timber-market to find the suitable timbers for the *Batavia* and his proposals to the board of the VOC to change slightly the charters. His work started with the charter he got from the VOC. With that information he was able to make a plan for the building. With the use of formulae he could draw and calculate the important elements of the ship. We are very lucky to have a pictorial source that witnesses this first stage of the building process. If we look more closely we see on his desk a book that probably contains his notes and formulae, even more important, a drawing of the keel, stem, stern and main-frame.

In Lelystad we followed more or less the same path. After the charter had been found, the first outlines of the ship could be drawn by using a list of formulae that was made by another shipwright, Jan Dirkzn. Grebber. He was younger than Rijcksen but already practising in the Amsterdam shipyards when the *Batavia* was built in 1628. In this list he gives all the important dimensions. By combining the data from the charter with his list we were able to find the other dimensions. At this stage we could make the same drawing Rijcksen had on his desk. From that point, a 17th century shipbuilder was able to start the building because his experience and his eye would guide him through. Since we did not have that experience at our disposal we had to go a step further in order to fill in the blank spots in the theoretical framework.

To answer the many questions about the building methods and all the small details we had to use the other sources. Most important are the shipbuilding manuals from Witsen (1671) and van Yk (1697). They are, firstly, a practical guide of how to build a 17th century ship. But they also contain many drawings of the ship's interior, details of construction and detailed specifications of ships that were built. Iconographic sources visualize the characteristics of the ship. Luckily we have a drawing of the East Indiaman *Salamander* (Nooms, c. 1623–64:fig. a10), a ship with the same dimensions as the *Batavia* and built 10 years later. Also a 17th century ship model of the East Indiaman *Prins Willem* (Ketting, 1979) is available for research. For the many construction details we had also the rich sources of the wreck of the *Batavia*, the *Vasa* and the Dutch ships found in the *IJsselmeerpolders* . As a last source I must also emphasize the many wooden constructions still available for study in the wooden houses and windmills in the Netherlands.

By combining these sources we not only understood them better, but we also succeeded in writing the same kind of manual for our ship. Our 'paper-reconstruction' contains, in the same way Witsen described the building of a specific ship, all the steps of the building process, the formulae used, construction details illustrated with drawings and a complete list of all the construction parts and their adapted dimensions (Vos, 1990). With this description we had the framework for the big experiment: the building at full-scale. As a next step we did some experiments on a small scale in order to check the reconstructed hull-shape. The question was whether or not it was possible to make this form out of oak planking?

Although at that stage we became acquainted with the many aspects of a 17th century East Indiaman the real learning process had not yet started. Because building a ship in reality is a different exercise from building one in mind and on paper, it was clear from the start that we were to be confronted with problems that we could not be aware of while reading the sources and looking at pictures and ship remains. We realised that, as long as we kept to our starting-point of authenticity, craftsmanship in an historical context and the right raw materials, we would build a machine that would not only generate questions but also would give us answers. Some of these questions could be answered by historical-archaeogical sources, others by the trade or the possibilities and impossibilities of the raw material. Most of the questions could be answered by a combination of these three.

The real reconstruction

Because it is beyond the scope of this paper to discuss the complex project in detail, I would like to illustrate the process of reconstruction building by three examples which also show the close cooperation between scholars and craftsmen.

One of the first practical problems we were confronted with was how to mark out all the separated components in a construction which is curved in all directions. The technique used for smaller boats consisting of cutting an element roughly and making it fit on the spot, could hardly be used on a ship with the dimensions of the *Batavia*. Almost every element in the ship weighs more than 100 kg. Nowadays, with modern lifting tackles, it is difficult to place a construction temporally

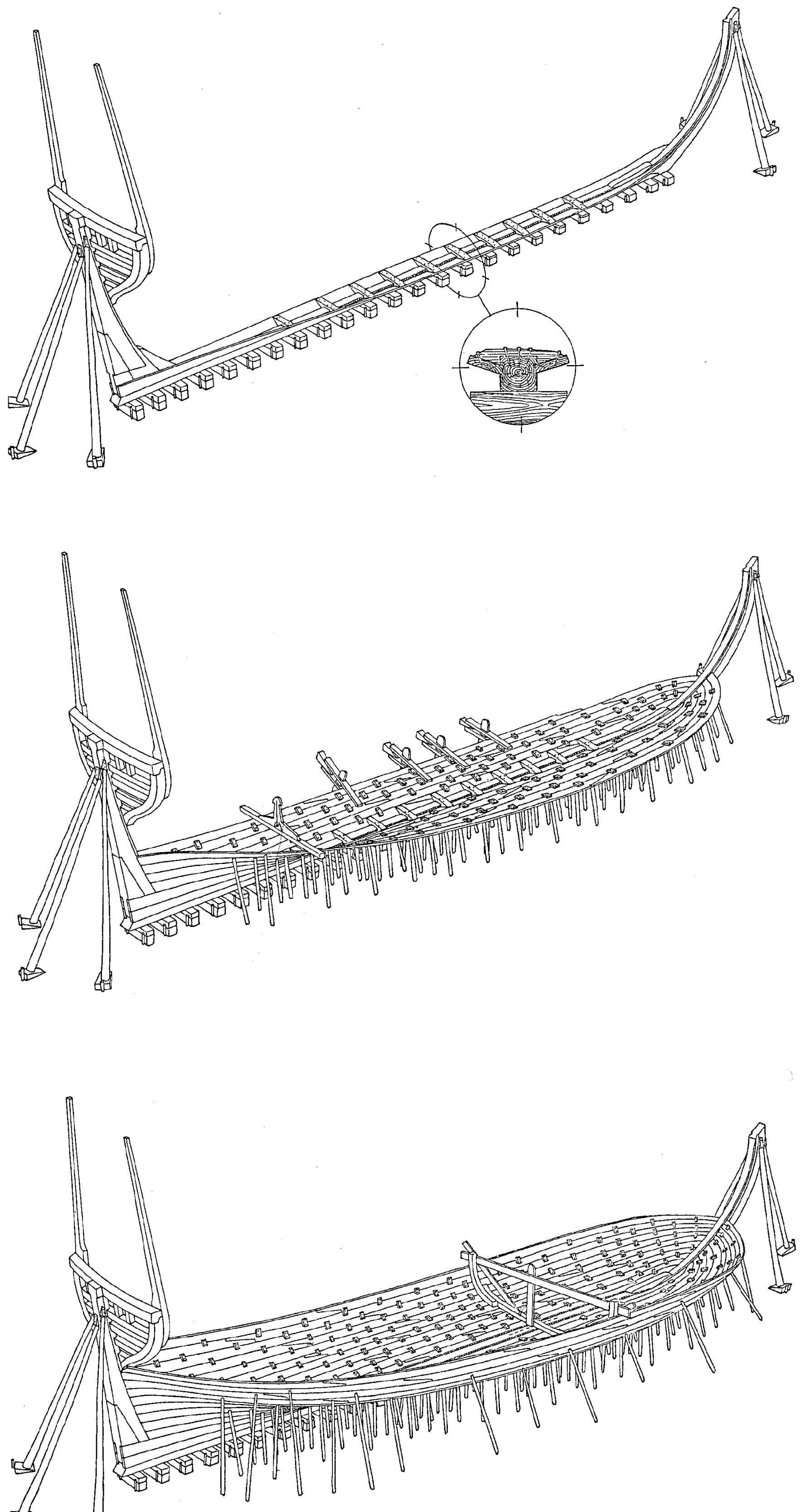

Figure 6. The stages of the construction of shell-first (after Hoving and Parthesius).

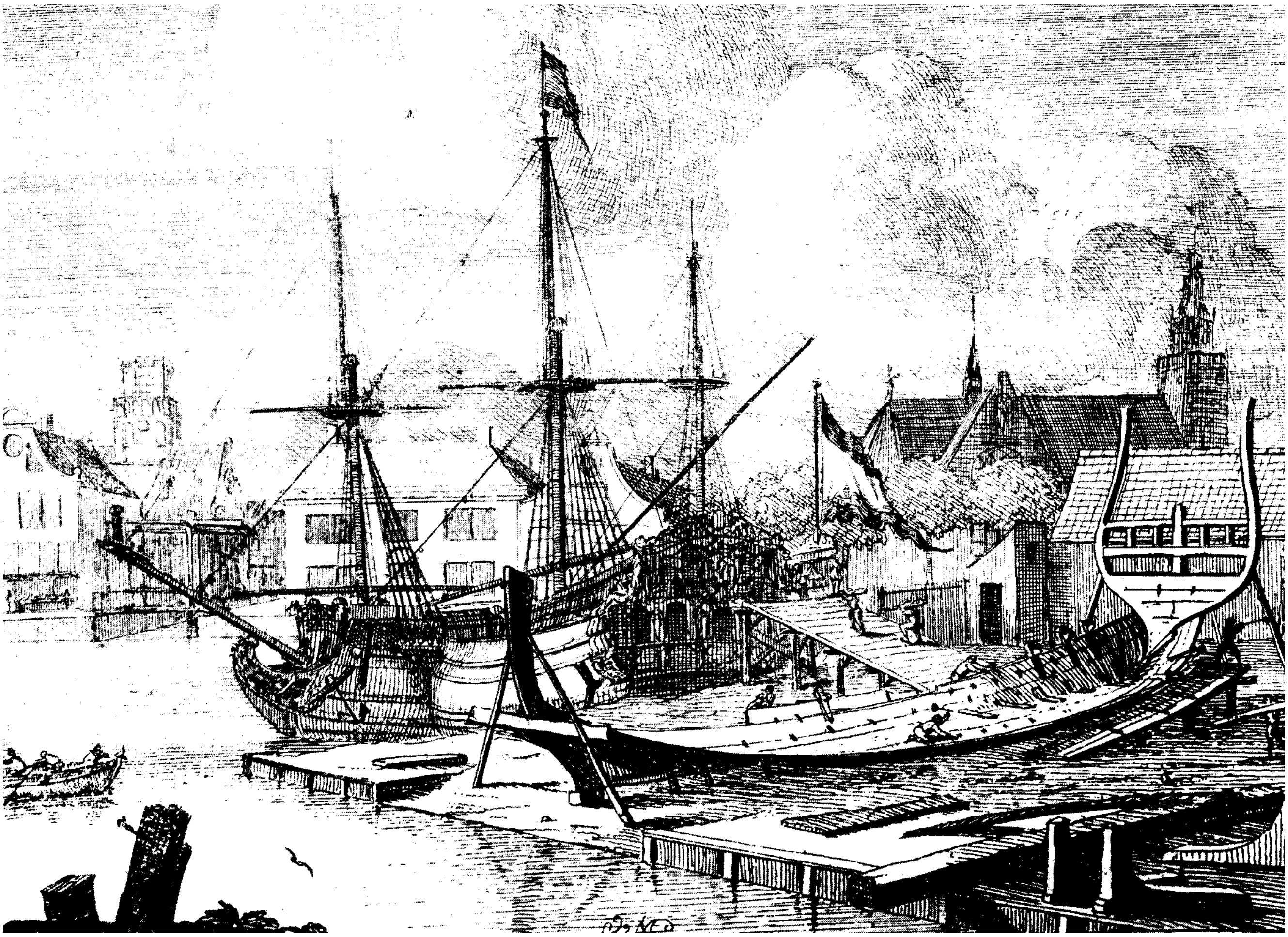

Figure 7. An illustration of shell-first construction by S. van der Meulen dating from the early 18th century.

and make it fit, but in the 17th century it must have been impossible to work in that way. Therefore we had to find a way to measure the construction on the ship after which the element could be prepared outside the ship. The measurements had to be so accurate that the element would fit exactly without having to be modified on the spot.

For shipbuilders in 17th century it was probably an even bigger problem. They had to find a system that could be used also by people with no proper education. By reading closely the manuals from Witsen and Van Yk we discovered the use of the so-called *Rij* (Yk, 1697). Although the use of this instrument did not seem clear at the beginning, we succeeded in reconstructing this measuring system. Step by step we followed their instructions which led us to the solution of our problem.

Figure 8. A painting of the East India Company shipyards at Oostenburg, Amsterdam painted by Ludolph Bakhuysen, 1696.

Figure 9. The 1:10 model of the *Batavia* under construction at the Western Australian Maritime Museum by Nick Burningham.

The principle is very simple: by fitting a flexible strip on the curved ship construction you get a two-dimensional straight line. The strip is divided by lines which are coordinates for the measurements. By connecting several strips to each other the curve of longer parts can also be measured. The only thing we had to do was measure and write down the results in a table. Later the same strips were placed in the same way on a rough piece of wood and we just had to take over the measurement to get a perfect fitting part. No complicated reckoning or projection techniques were needed. This system turned out to be useful for many parts of the ship. For more complicated forms we used moulds, as they did in the 17th century. This illustrates how historical sources bring us to the solution on the level of practical organisation.

After we had learned to work with the *Rij,* the fitting of the hull-planking was easy. Making the planks was now simple, bending them was another problem. Historically we knew that they were bent by open fire. Many paintings and drawings of shipyards show the burning of straw under a strake. We first tried to bend the strake by open fire on the ground and the strake in a gantry above it. This method did not work because it caused too much tension in the wood so the strake cracked. After trying several variations we started to use small gas burners. It was possible to move the flame from one place to another in order to give weak spots in the wood extra heat. Now we understand better why they were using strawfire instead of longer burning wood and coals. The intense heat of the quick burning straw could be easily moved from one spot to the other. Without futher problems we then could bend strakes of 10 cm thick and wales up to 20 cm. Only on the thickest wale in the head of the ship, where the curve is extreme, we got a light crack. Luckily we came as far as our forefathers because the wale on the *Vasa* has, on exactly the same spot, a similar crack.

The bending of the strakes normally takes between 4 and 6 hours. For the wale we needed over 9 hours to get it in shape. When it reached the required curve it was fitted, whilst still warm, on the ship and nailed to keep it in place.

Besides reconstructing a part of the ship based on a combination of several sources, it was also possible to use the method of replicating (making a copy of an existing object). That is what we did with the guns. There are two reasons why we replicated the guns: firstly, the working and production of the guns are, in principle, quite simple and well known, so we did not have to experiment with the construction; and secondly, from the archaeological finds we knew that several types of historical guns from the beginning of the 17th century were used on East Indiamen (Green, 1989). These guns are still subject to research of the development of ships' armament in the late 16th and 17th century. The main questions relate to the production areas in Europe and the success of the Swedish guns on the Dutch market starting at the beginning of the 17th century (L'Hour, 1989). To contribute to this research we decided to replicate as many types of guns from this important period as possible to get a clearer understanding of their performances. In combination with the ship it will raise a number of questions, related to the manning of guns and crew under real live conditions.

According to the resolutions of the VOC the *Batavia* was equipped with 32 guns: 24 from iron, 6 from bronze and 2 from copper, lead and iron, the now so-called composite guns. On the wreck of the *Batavia* several iron guns were found and a few are conserved. These were not enough for the replication of all the types required. Luckily in 1985 iron guns were also found on the *Mauritius*, an East Indiaman wrecked 20 years before the *Batavia* on the west coast of Africa. From these two wrecks and another Dutch wreck of that period found in the Waddenzee we chose a representative collection. Exact measurements were taken and made into construction drawings. These drawings were used as a basis for making wooden moulds, that were used for the sand-casting moulds at the foundry.

The casting of the 24 iron guns took place at a large commercial foundry. This year we hope to add the finishing touch by testing them in order to get our certificates for further experiments.

One of the most important elements of a reconstruction is the knowledge of the materials. Wood was initially the main concern. A great deal of expertise on the part of Willem Vos was needed to find all the forms and qualities required to build a ship of this size. In most cases he found the wood by travelling in Europe, but sometimes it was not that easy and we needed some luck. This was the case with the pockwood for the pulleys. This wood is not available anymore, as there are almost no trees left. We were already looking for an alternative, when some wood in storage was found in Hamburg.

The research about the raw material was essential for the success of the experiments. A good example is the ropes of the *Batavia*. The rigging is one of the most complicated parts of the ship. It was also, in the 17th century, a subject of discussion as shown in the many publications. Through written descriptions, drawings and paintings the development of the rigging in the 17th can be followed. By compiling these sources, it was possible to reconstruct the rigging of an early 17th century ship on paper (Westera, 1990; Green, 1991). The next step towards the full scale reconstruction of the rigging was the rconstruction of a scale model. In this way choices could be made between solutions for a particular construction. Also the problems of the connection between rigging and construction could be revealed.

After some modifications the rigging-master started ordering some samples of hemp. The different dimensions of the ropes were extracted from the detailed lists that were printed in the 17th century. The real problems started when we tested the hemp for its strength. Since we already made the masts and yards we could calculate the strength that was needed for the ropes. Surprisingly the ropes with the specified dimensions were not strong enough. What was wrong? At first we thought we had made a mistake with the interpretation of the sources. We had to do our homework all over again. However no mistake could be found. However, a discussion was found in one of the shipbuilders' manuals about the quality of hemp the ropes were made of. That put us on the trail to compare our ropes with the ropes found on the *Vasa* and on a recently discovered wreck from around 1585. There we found the solution: modern hemp is made from short fibres while the hemp from archaeological sources was made from long fibres. Now we understood the reason, but we did not have a solution to the problem. Were could we find '17th century hemp'? The answer was we had to make it ourselves! Again we had to look around in Europe for a plantation were they grew hemp, for one reason or another, taller. We found this in Italy and Eastern Europe. With this hemp we were able to twist the hemp ropes on a 400 m rope-walk in the Netherlands. A year later we had our '17th century ropes' that were now strong enough to play their part in the 17th century rigging.

Shell-first or frame-first?

The potential of this kind of research is high, provided you use the right starting-point: by integrating the historical-archaeological research into craftsmen's knowledge and the use of the correct raw materials, a lot of new knowledge about 17th century East Indiamen and the building techniques can be collected. Science alone is not the answer as it lacks the craft skill that is needed; the *Batavia*-project has the advantage that, to a large extent, the ship can be built by eye (rule of thumb).

However, it was not possible to follow the historical steps at all stages of the building process. This was the case in the very beginning, when we had to decide the method for the construction of the hull. Historically two methods could be used: the 'shell-first' method and the 'frame-first' method. Both were used during the 17th century.

Although we are now quite certain the *Batavia* was built shell-first, it was decided to build the ship frames-first. Too many questions about the practical implications of the shell-first method remained unsolved. How did they keep strakes with a weight up to 350 kg in place without the support of the frames? What method was used to shape the hull with only temporary placed strakes? All these questions, at a moment when we were less experienced than we are now, made us decide to use the frames for the support of the strakes and as guiding lines in the shaping of the hull. Now, after nine years, we think we can solve these questions. Our next big ship will be built shell-first. We have learned to appreciate the skill of the 17th century shipbuilder, but now we also recognize the limitations of their techniques and the problems they had to solve. By building the ship we now understand more of the concept of the Dutch way of building and the solutions the shipbuilders chose during the course of developing a specific type of ship meant for a specific purpose.

As it should be, we are left with more questions on this subject than we had when we started. But these questions are now on another level and more detailed. I would like to give one example of how our experience can be combined with broad historical research on the development of shipbuilding in the 16th and 17th century on one side, and archaeological research on a specific ship in that period on the other. At the end of the 16th and the beginning of the 17th century many technical problems arose concerning the increase of the size of ships. The development of the rigging is the most noticeable indication of that process. Less clear are the changes in the ship's construction and the building practice. By building a ship we now understand much more about the constructional concept of making bigger ships strong enough. It is possible that the change in construction methods from shell-first to frame-first occurred because it simply was not possible to handle the correspondingly bigger strakes. A strake on the *Batavia* reconstruction was 11 cm thick and about 350 kg in weight. To keep these in place without a construction element such as the frames, they needed to be connected to each other by wooden clamps, chains and wring-staff, and rested on temporary poles. Questions already have been raised as to whether or not this was the reason for change during the 17th century from the shell-first to frame-first method. These questions became even more interesting when it became clear that the two East Indiamen *Mauritius* and *Batavia* were not built in the manner described by Witsen and van Yk of one thick hull plank covered with a thinner layer of protective planking. Instead, the vessels were built with two thinner layers of planking and a third layer of protective planking as well. Keeping in mind that the East Indiamen in this period represented the largest group of ships, it is possible that this method was the shipbuilders' solution to the problem of building bigger ships shell-first. They simply made the hull out of two thinner strakes instead of a thick one. Instead of wooden clamps they could also use a complete strake to connect the strakes with each other. But these are all speculative assumptions. Why should it not be just one of the shipbuilding traditions used in both frame-first and shell-first methods?

Figure 9. View of the rigging on the *Batavia* replica, Lelystad.

Archival references make it even more complicated because the VOC already had ships covered with an extra layer of planking between the existing two (Leenstra, 1990, 1991). Or possibly it was just an adaptation for the special requirements of VOC ships to avoid maintenance overseas? In the first decades of the 17th century, VOC ships had to last for more than two years overseas without proper repair facilities. Was the extra skin between the traditional skin and the pinewood protection against the teredo a similar adaptation to the double number of stays and the extra gear and equipment they took for their long journey, or was it a solution for building bigger ships along the traditional shell-first method? To make matters even more difficult, recently an extra skin was also found on a ship from about 1585 in the Waddenzee (Maarleveld, 1994: 155). Futher research, historical, archaeological together with experimental archaeology must bring more light on these questions.

Experimental and reconstruction archaeology

The reconstruction of the *Batavia* has provoked a number of questions from which a complex research program could be developed. The project should be considered to be a form of experimental and reconstruction archaeology, since the scientific objective of the exercise is to learn about building and sailing a 17th century ship.

At a number of levels, this project can be used to increase knowledge of the past in a way that is not available through conventional research methods. Although it is understood that these questions exist, they are rarely addressed by historians and archaeologists.

The discipline of experimental and reconstruction archaeology is young and far from scientifically accepted. This is not a new problem when you are operating in this field, since the same could be said about maritime archaeology 30 years ago. The problem is that the discipline itself does not have a proper research methodology. Quite frankly it is also impossible to design a common valid method. Since the subjects of this discipline vary it is important first to find out what the potential of this kind of research is before we try to confine it to a methodological strait-jacket. It is my opinion that every initiative has its value provided you say what you are doing, why and how. With this project we hope to contribute to the growing maturity of the discipline, a better understanding of the 17th century East Indiamen and—after our sailing phase—about the handling and characteristic of a ship and rigging of that period.

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Maritime graffiti in Oman

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Figure 1. Bahla fort, exterior view, 1994.

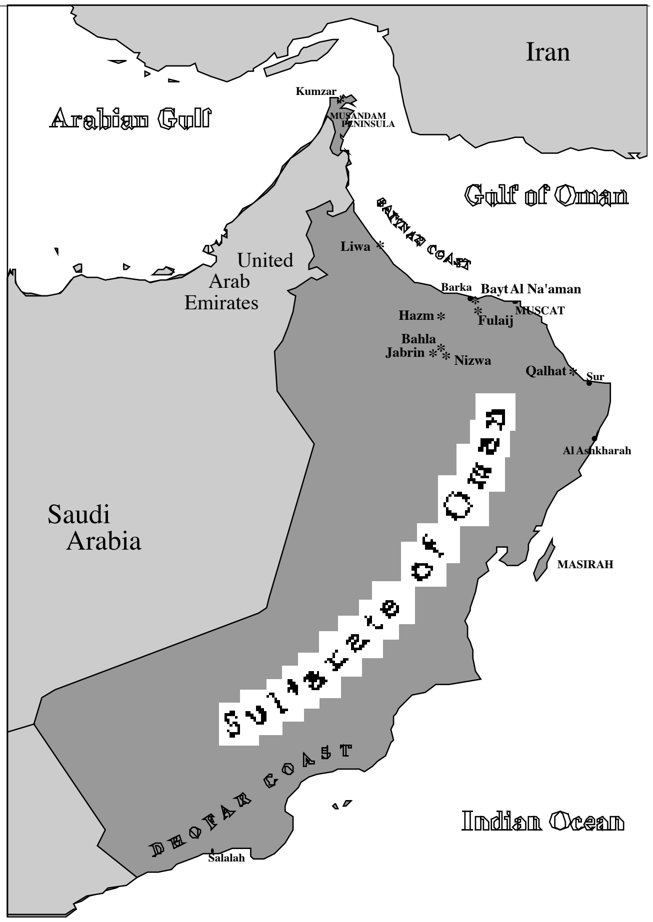

Figure 2. Map showing locations of forts mentioned in the text.

Introduction

During the past 5 000 years the political and economic power of the Sultanate of Oman has always been intrinsically linked with the vigour and strength of its maritime activities, and the fortunes and influence of Oman rose and fell in step with the intensity of maritime activity. Despite the importance of its maritime heritage, little study has been done so far on the vessels which enabled Oman to exert its influence in the maritime sphere.

A lack of information about Omani ships plagues the maritime archaeological record, with no Arab vessels from the region having been discovered. However, some recent discoveries from a land site on the Indian Ocean coast near Ra's al Hadd give a hint to what may have existed about 4 000 years ago (Cleuziou & Tosi, 1993). Thick slabs of bitumen preserving on one side the impressions of reeds lashed together with rope, and on the other side the remains of barnacles, point to the use of reed boats. Similar techniques are still used for building boats in Iraq today (Thesiger, 1964). Archaeologists have discovered stone anchor shanks near Ra's al Hadd (Tosi, 1994 pers. comm.) and in several places along the Dhofari coast, but the dating of these is uncertain (Owen, 1994, pers. comm.).

During the past five millennia, short references to Omani ships and shipping have occasionally appeared in the writings of scribes, travellers and historians. Some of the earliest references to shipping occur in cuneiform tablets of the Akkadian kings, which mention the presence of 'black ships of Magan' (Oman) in Sumerian ports. Approximately 2 000 years ago, the anonymous author of *The Periplus of the Erythreaen Sea* (Huntingford, 1980) commented on the sewn boats of the region, as did several after him including Procopius in the 6th century, Marco Polo in the 13th and the Portuguese in the late 15th and early 16th centuries.

The existence of ship graffiti (that is the subject of this paper) testifies to the abundance of local and international seaborne trade from the 1700s onwards. With the departure of the Portuguese in the mid 17th century, Oman entered a period of relative prosperity and unity. The unity was characterised by a surge of national energy directed toward expelling both the Portuguese and European presence in Oman and neighbouring countries and this was known as the 'The War of the Arabian Sea'. The coastal ports had always been able to subsist and prosper from the seaborne trade, but new benefits were to be gained from combining maritime interests with those of the interior. Together, the agricultural surplus and profits from the maritime trades created a buoyant economy. It was during this period, that forts and fortified palaces, and villages, were funded and built (Facey, 1979: 64–66). The evidence of ship graffiti in the interior forts, separated from the sea by the 3 000 metre Jebel Akhdar range, symbolises the unity of the coast and the interior (Facey, 1979: 66).

Substantial naval fleets were also maintained. For example, Ahmad bin Said in one famous naval battle (1775) sent ten square-rigged and over 100 smaller ships against the Persians at Basra. Oman's territory extended at times from Dhofar to Ras Musandum, to Iran and adjacent islands, and the east African coast.

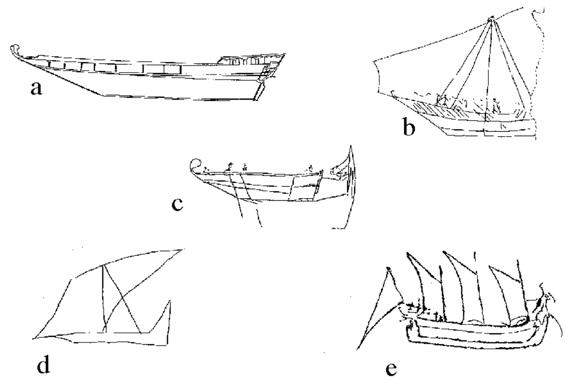

Figure 3. Ship graffiti from the fort at Fulaij, redrawn from the originals.

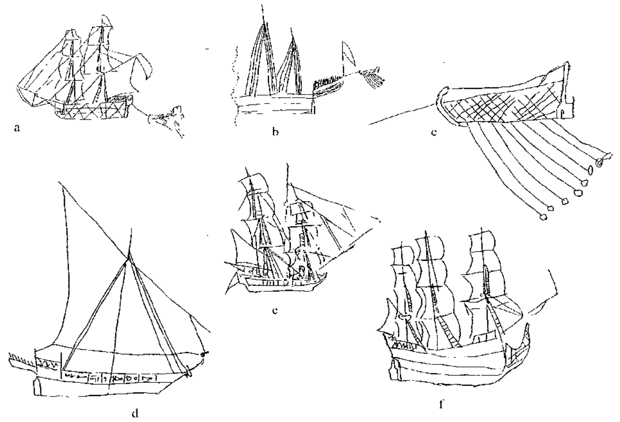

Figure 4. Ship graffiti from the fort at Fulaij, redrawn from the originals.

It is well known that sewn-plank boats were ubiquitous in the western Indian Ocean for centuries and some are still being built in parts of India, on the East African coast and in the Lakshadweep islands. Until two decades ago the sewn *sambuk*, or *kambari*, was still being built in the southern province of Dhofar in Oman. In the north, vestiges of a sewn plank tradition can still be found. Boats built in the 1970s in Musandam and on the Batinah coast often have the hood ends of their planks fastened by sewing. But beyond the sewn tradition, and some drawings from the mid-nineteenth century from a few Europeans such as Amiral E. Paris (1841) or J. Edye (1834), little is known about the ships of Oman and the western Indian Ocean from past centuries.

Many examples of traditional Omani vessels exist in Oman, and some information about ancient Omani vessels can be learned from the study of these vessels. However, most of these boats are in very poor condition, the majority are not more than 40 years old and none would be much over a century. Some once common types have disappeared only within the last two or three decades and most of those that remain are relatively small boats. There is only one example of a *ghanjah*, the transom-stern trading vessel that was one of the more important types in the last 200 years. Its larger relative, the *baghla*, has completely disappeared, along with the classic large *battil* and *baggarah*. There are a few of the cargo *badan*, but only one is in reasonable condition. No *boom* are registered in Oman (though motorised versions may be seen in Dubai) and very few *sambuk*, *abubuz* or *jalibut* exist.

Projects

In recent years the existing traditional vessels of Oman have been closely studied by staff from the Western Australian Maritime Museum, assisted by Earthwatch volunteers and representatives from the Institute of Nautical Archaeology in the United States, and the Nautical Archaeology Society in the United Kingdom. Four expeditions between 1992 and 1995 have catalogued most of the existing traditional craft and rigorously recorded a selected number of them (Vosmer *et al*. 1993a & b; Vosmer 1993c & 1994a). A broad base of information about the design, construction, materials and uses of the vessels has been learned from these investigations, although only limited information can be gained from a resource as relatively young as the extant boats.

During the three most recent Oman expeditions, another resource that can yield some information about the vessels which sailed the Arabian Gulf in the past was discovered – the maritime graffiti that exist on the walls of fortresses (Fig. 1) and merchants' homes, or on cliff faces of wadis and inlets. Most of these graffiti date from the mid-seventeenth century to early in the present century. The opportunities for discovering graffiti are plentiful – ramparts of fortresses are seen in every major town in Oman, and isolated forts are found throughout the country. There are numerous homes of prosperous merchants and unlimited numbers of rock faces that can be examined for nautical iconography.

During 1993 and early 1994, nine forts were examined for graffiti (Vosmer, 1994b). Of these, one was coastal (Barka) and eight were inland. Nautical graffiti were found in five of these, all of them inland. Fulaij has the largest number of graffiti, but Hazm and Jabrin also contain several graffiti. Nizwa had two ship representations, both in company with graffiti of riders mounted on horseback, brandishing weapons. The graffiti at Bayt al Na'aman were the most puzzling and are referred to further below.

During the fieldwork season of December 1994 an effort was made to systematically investigate a further fourteen forts for evidence of graffiti. Permits were acquired for the restored inland forts at Nizwa, Sumail and Al Rodaidah and, the coastal forts at Al Maqa'ish, Sohar, Shinas and As Suwayq. The restoration of these forts has, however, rendered all the walls pristine and devoid of any incised carvings or painted images, although Nizwa does preserve two examples. Several unrestored forts and associated buildings were then investigated in the hope that graffiti may still be visible. This proved a successful strategy. Both the fort at Liwa and the mosque at Bahla have examples of traditional, hybrid, Indian and European vessel designs.

Figure 2 shows the location of forts and associated structures that contained ship graffiti. The following article describes the boat types represented in each fort. The text is accompanied

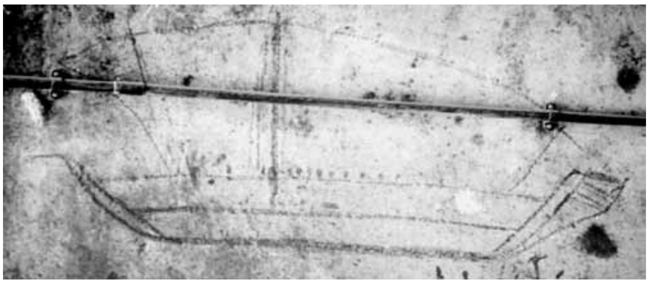

Figure 5. Drawing in Hazm Fort of an East African *mtepe*.

by a number of figures (a picture speaks a thousand words), to aid in interpretation and comparative analysis of the resource. Some general comments on 'graffiti' culture are followed by recommendations for future research into boat iconography in Oman.

The graffiti

Iconography is very often difficult to interpret, and most of these graffiti are no exception. The form that the graffiti takes includes images that are incised and those that are painted. Incised examples have been scratched into the adobe, plaster or cement walls, columns and window apertures of the forts using sharp implements. Rock surfaces supported images pecked into the face by a technique of using repeated heavy blows to a blunted tool. Painted illustrations include the lamp-black wash in forts and white wash on rock surfaces. While a few are exquisite renderings, others have been crudely done, sometimes evidently executed by someone with little artistic talent or powers of observation. Others may have been executed by someone with artistic talent but little knowledge of ships and boats. Certainly the ones found in locations away from the coast were done from memory or at least not from direct observation. Some are damaged, partially worn away by human traffic, obscured by soot, dirt or modern graffiti. Many illustrations have been engraved over earlier ones, giving the effect of multiple transparent layers and making individual interpretation more difficult. Despite these problems, one cannot believe that each of them, whether crude or technically accomplished, damaged or not, has nothing to offer. They can tell us something about the types of vessels that sailed in Omani waters, something about Omani contacts with foreign cultures, and something of the people who created them.

The sizes of the illustrations vary from a few centimetres to about 1.5 metres, and all the ship graffiti we have seen in Oman are starboard or port elevation views. The vessels range in style from purely Arab vessels, through hybrids of Arab, Indian and European design, to African, to pure European. The Arab ones usually can be recognised by their long straight overhanging 'grab' bows, counter sterns or settee sail rigs (e.g. Figs 3a, b, c, d, 4b and d). The others display features peculiar to their regions, such as gaff rig (Fig. 3e) or multiple square sails in the European or hybrid European/Arab vessels (Figs 3a, e and f), or a single square sail in the African or hybrid African/Arab examples (Figs 4 and 13).

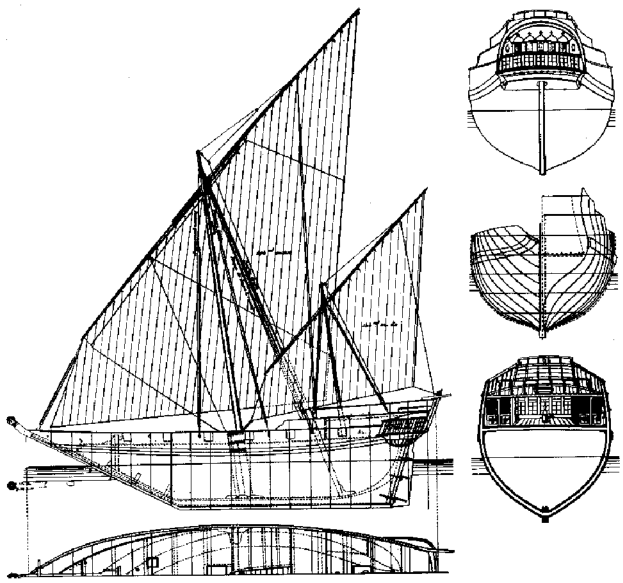

Figure 6. Drawing of a *baghla*, from Amiral E. Paris, c. 1840.

The forts

Fulaij

A few kilometres inland from Barka, the fort of Fulaij, a former royal household, contains several enchanting displays of ships and boats. Though the fortress has been restored, care was taken to preserve the graffiti on the interior walls. Wooden frames have been set into the restored walls, delineating the preserved sections. Inscribed in detail on the wall of one passageway is the hull in port elevation of what is obviously a *ghanjah* or *baghla* (Fig. 3a). The precise identification of type is impossible, because the primary identifying characteristic—the stem head—has been damaged and could be either that of a *ghanjah* or *baghla*. It is an exquisitely rendered engraving. So detailed is it that one wonders if the artist had a reference illustration as a guide. It is a sleek vessel with straight keel, long bow overhang and gently curving sheer. The windows on its quarter galleries are delicately rendered—even the mullions of the windows are depicted. It is unfortunate that there are no masts or spars, no rigging of any kind. These vessels are known to have had from one to three masts, and could have been rigged with the standard Arabic settee sails or western square sails. In the early 19th century, Edye illustrated a similar vessel of about 26 metres in length (Edye, 1834). That vessel had one mast and must have set an enormous settee sail. Slightly later in the century, Paris also illustrated such a vessel (Paris, 1841; Fig. 6).

Featured on the same wall as the *ghanjah/baghla* is a classic *battil* (Fig. 3c) showing the characteristic 'club-shaped' stem-head and the distinctive stern profile in the shape of a stylised dog's head, similar to a type seen in Musandam today (Fig. 7). A long, very deep rudder is fitted, and there appears to be some sort of decoration on the 'dog's head'. The decoration could be interpreted as depicting the strips of cowry shell seen on the modern *battil* or *zarooqa* (Fig. 8). The keel exhibits a strong upward sweep near the stern, distinctive of both the vanished classic *battil* and the smaller modern version. Two

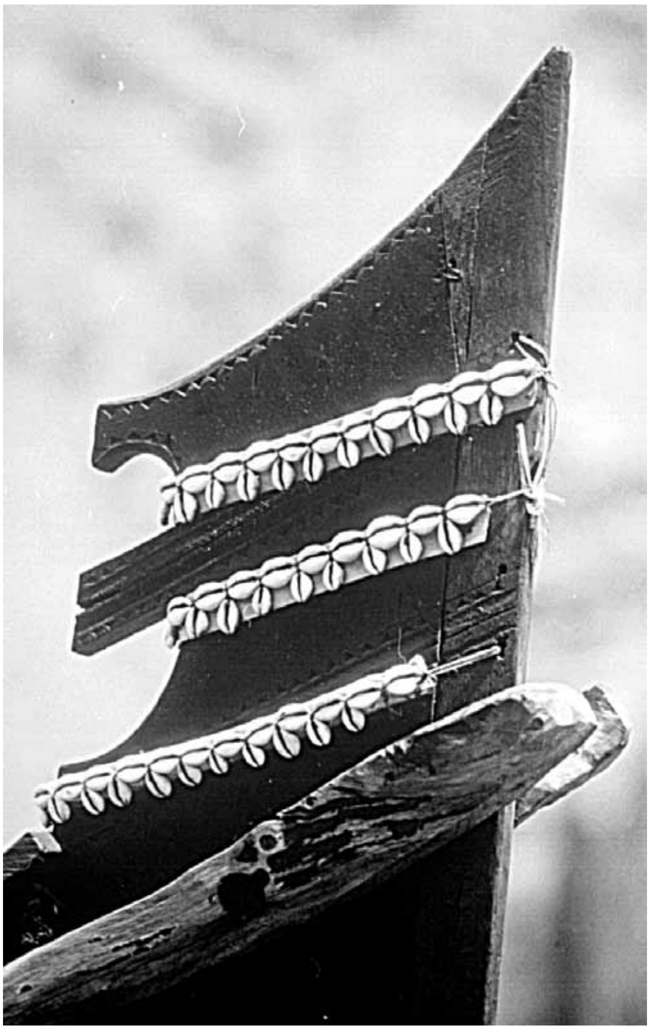

Figure 7. Stern fin (*fashin*) of a modern *battil bahwy* from Musandam, retaining vestige of the traditional 'dog's head' motif.

Figure 8. Stern fin (*fashin*) of a contemporary *zarooqa* from Musandam.

diagonal lines across the hull may represent oars, as there is no sailing rig shown. Above the gunwale near these 'oars' are two indistinct figures that might be oarsmen. Nearby is a representation which, though crude and extremely simple, is clearly a *badan* (Fig. 3d).

Also on this wall is a three-masted gaff-rigged schooner (Fig. 3e), certainly a foreign vessel in these waters. The wall opposite holds an illustration of a large square-rigged vessel towing a smaller boat with eight oars per side (Fig. 4a). The 'mother ship' is a brig, probably dating from the first half of the nineteenth century. It displays a royal sail on the foremast, a spanker on the main, and no main course. A curious feature of this drawing is the 'x-ray' view: at least one mast is shown extending to the keel, revealing structure that is normally hidden. The large 'X' marks on the hull may also be hidden structural detail, perhaps representing the diagonal metal strapping introduced to wooden ships in the mid-nineteenth century. If these marks do indeed represent the diagonal bracing, it may have been a new invention which impressed the artist who felt it important to represent this technological innovation. The rig is a little more detailed than most illustrations, depicting forestays, some shrouds and ratlines, a bowsprit with a dolphin striker and a jibboom fitted to the bowsprit. Like many of the vessels in the Omani graffiti, this one displays large flags.

Another drawing at Fulaij shows a large Arab vessel towing a multi-oared small boat similar to the previous drawing (Fig. 4b). The small boat (Fig. 4c) has a recurved prow, stern castle, an axial rudder, and a hull which is covered by cross-hatching on the lower parts of most of its hull. Cross-hatching frequently occurs in ship and boat graffiti in Oman, but its interpretation is uncertain. It seems more decorative than functional in this drawing. Like the previous one, this small boat has eight oars per side. If the number is reliable, we could estimate the length of the boat at about twelve metres, allowing approximately one metre per oarsman per side and about two additional metres at either end. While it is not known exactly what type of small boats these drawings represent, it is certainly not one that survives today. The bow of the larger ship has unfortunately

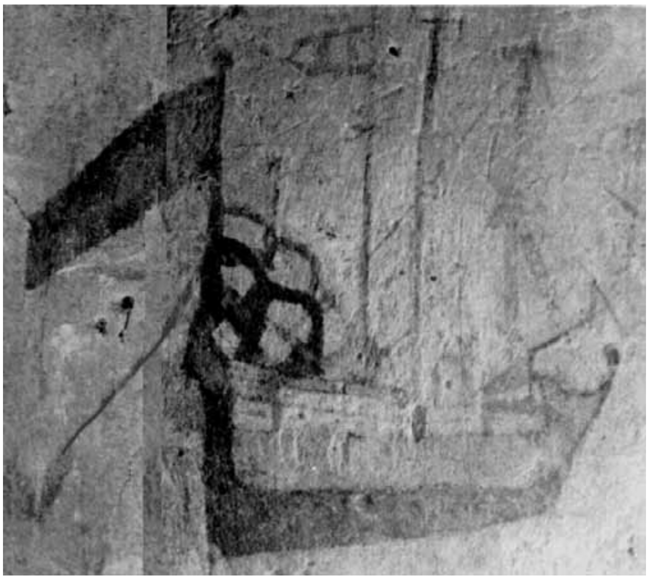

Figure 9. Illustration from the cannon embrasure of the south-east tower, Jabrin castle, left side of embrasure, 17th–18th century.

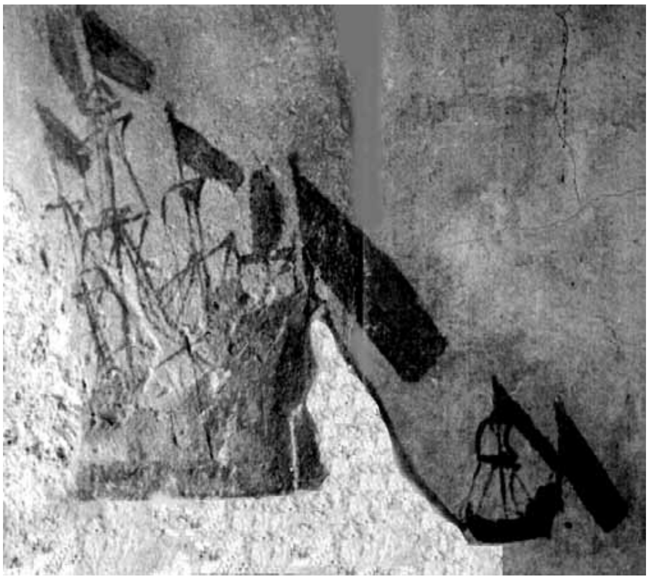

Figure 10. Illustration from the cannon embrasure of the south-east tower, Jabrin castle, right side of embrasure, 17th–18th century.

been obliterated by over-plastering, but enough of the original survives for us to see it is an Arab hull, with two masts, but no sails set. The long overhanging counter stern is distinctive and characteristic of Arab vessels of the early 19th century. It resembles the counter stern of another ship drawing from Fulaij (Fig. 4d). Here we see a vessel with a 'grab' bow, single mast with settee sail, a stern castle and long counter. A model of an Arab ship in the collection of the Science Museum in London, said to date from 1830 displays an identical counter stern. These structures are true counter sterns and if the early 19th century date is correct we may credit the Arabs with the invention of the counter stern. In additional to the long overhanging stern, the model displays a stem head very much like the ones seen on *baghla*.

On other walls, or tucked into window apertures in the massively thick walls are other illustrations, of square-rigged ships under full sail, bristling with cannon, pennants streaming from their mastheads. Some of these have typical European hull forms, and reflect the presence of foreign shipping and navies in Omani waters. One example (Fig. 4e) is scratched into the wall of a window aperture in the narrow staircase to the second level of Fulaij fort. The vessel is a brig, showing a royal sail on at least the mainmast (the upper part of the foremast is unclear). This is a rig configuration not introduced until about 1790 (Lees, 1979), pictured on a hull whose design appears to date a century or more earlier. The hybrid of late 18th century rig with earlier European-style hull form is repeated in other graffiti in the fort, as in a three-masted vessel setting royals on all masts, but with stern quarters reminiscent of Elizabethan galleons and a 17th or early 18th century bow. These hybrid designs are clearly either Arab vessels with European influences or works of imagination. Many of these square-rigged vessels are stylistically related and may have been done by the same person or perhaps even copied from a book of illustrations.

Jabrin

The depiction of a ship towing a small vessel astern frequently appears in Omani maritime graffiti, as for example in two illustrations on either side of a cannon embrasure in the castle at Jabrin (Figs 9 and 10). The drawings are believed to date from the late 17th or early 18th century. They are not engraved, but painted on the walls with what appears to be a lamp-black-based wash. Each of the ships depicted here is towing a smaller boat astern, a practice common in the region which has survived to the present century. It is said that on a recent dhow voyage out of Lamu in East Africa to Zanzibar, the vessel was towing a miniature of itself–exactly what we see in the Jabrin paintings. The Jabrin vessels are square-riggers with enormous flags fluttering from their mastheads. In his book *The Dhow*, Hawkins (1977) makes reference to the habit of Arabian Gulf dhows of this century displaying enormous flags in port, each crew attempting to outdo the others with the sheer size and exuberance of their banners. Perhaps the practice is traditional and was common 200 or 300 years ago.

The passage leading to the south-eastern tower at Jabrin also contains ship illustrations, done in a dark red wash, but largely obliterated by soot stains from lamps and torches as well as more recent graffiti. They are square-rigged vessels, but only the tops of the masts and topgallant or royal sails are visible. They do include, however, details of lifts for the yards. Just inside the heavy tower door there are other graffiti, most too damaged to interpret properly.

Hazm

In early 1994 the fort at Hazm was undergoing restoration, but retained much of its original interior, the plaster blackened by centuries of oil lamps and torches. On the entrance wall beyond the massive wooden doors of Hazm fort a mysterious vessel is painted (Fig. 11). Although it bears slight resemblance to the rowing vessels depicted at Fulaij, this vessel is distinct from

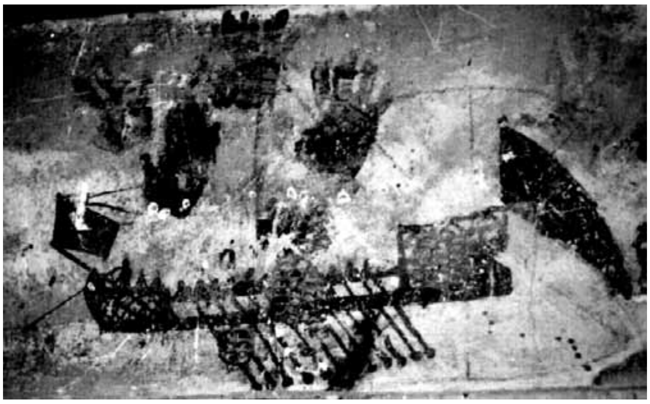

Figure 11 . Illustration in entrance to Hazm Fort.

Figure 12. Hybrid vessel with square sail, Hazm Fort.

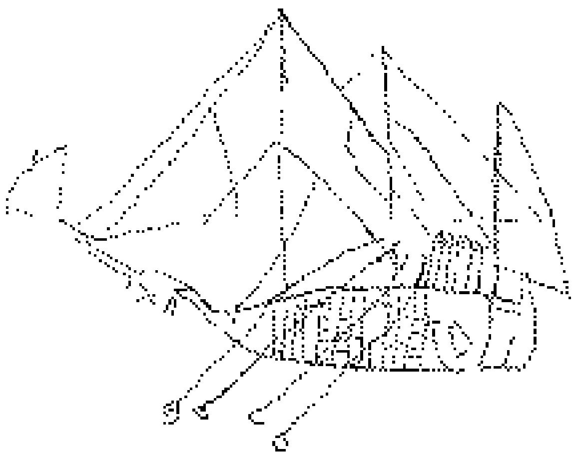

Figure 13. Three-masted vessel with four oars and net or wicker work on side, at Fulaij.

Figure 14. Crudely-drawn vessel displaying common 'zig-zag decoration (lashing?), surrounded by 'fish', Bayt al Na'aman.

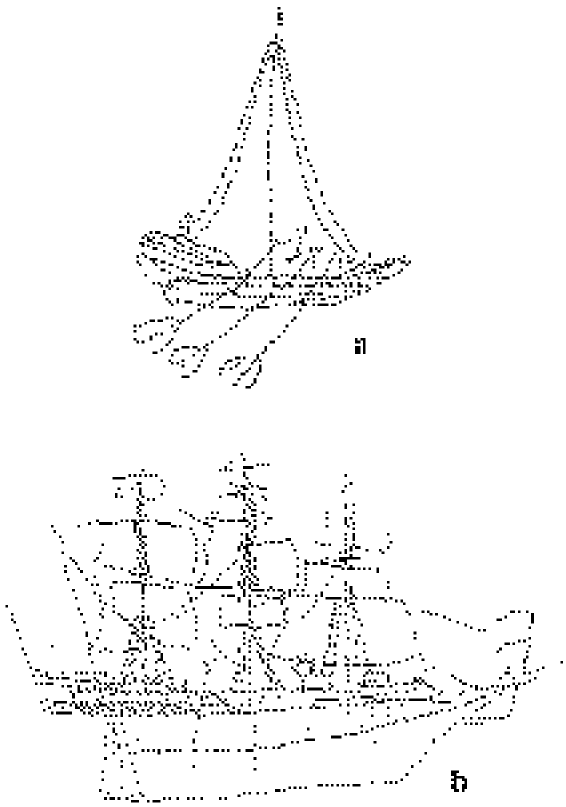

Figure 15. a. Small vessel from Bayt al Na'aman tower. b. Large square-rigged Arab vessel, with sun motif. Note counter stern.

any other seen in Omani graffiti. The hull is long and straight, with a recurved bow, an axial rudder and a stern castle. The stern castle and the bow are decorated with complex cross-hatched lines, a common motif among the illustrations. The vessel closely resembles Mediterranean galley-type designs. Men at oars are depicted (twelve oars are shown on one side), and another man busies himself hauling in the anchor. Perhaps this is meant to illustrate the manoeuvre of rowing up on the anchor to get underway. From the bow flies a rectangular flag and ribbon-like streamers, while from the stern hangs another enormous flag.

Another unusual drawing at Hazm, unfortunately defaced with electrical conduit, shows a double-ended vessel with one mast, a single large square sail and a 'camel-head' stem (Fig. 5). A third rendering, also defaced, shows a boat with a typical 'grab' bow terminating in a round finial like a *ghanjah*, but a stern more like a *boom* (Fig. 12), and a single square sail. The rudder has a yoke for the steering lines, like a *boom*. The drawing is unfortunately crude and lacking in detail, but illustrates another interesting hybrid design, one not known from the existing body of vessels in Oman. The square sail is rare in the Arabian Gulf but is known in East Africa. With its

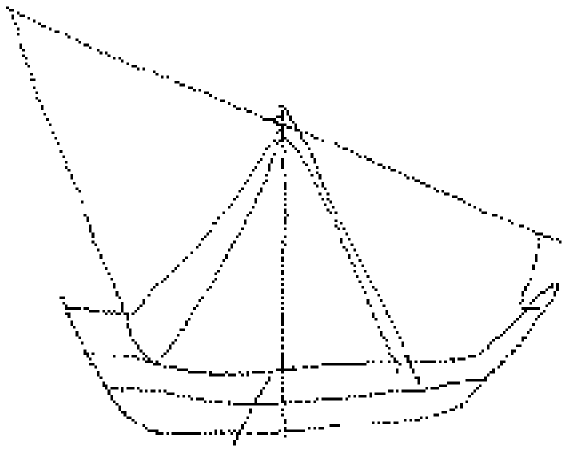

Figure 16. Graffito from Bahla mosque, illustration of a *boom*.

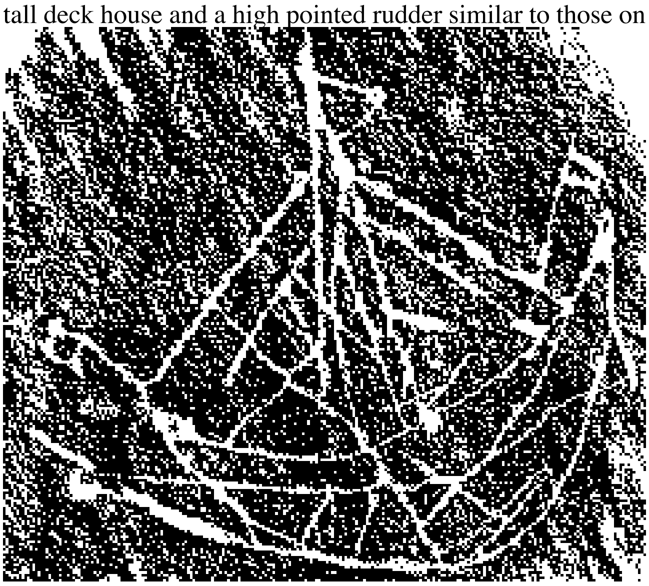

Figure 17. Graffito from Bahla mosque, incised illustration of double ended vessel.

'grab' bow, a lofting bowsprit, three masts, what is apparently a tall deck house and a high pointed rudder similar to those on Omani double-enders from past and present such as *battil* and *badan*. The rig is very difficult to interpret, but the vessel has four oars or sweeps with their blades placed forward as if at the beginning of a stroke. The side of the ship is covered with a lattice-work design that may represent the matting used as a washstrake to protect crew and cargo from spray, or perhaps a net. Paris, in his *Essai sur la construction navale des peuples extra-européens* pictures a vessel fitted with washstrake matting which looks very similar to this (Paris, 1841), and photographs in *The Dhow* echo the pattern as well (Hawkins, 1977).

Bayt Al Na'aman

A few kilometres from the coast near Barka is the fort called Bayt al Na'aman. On the walls between the gun embrasures in its south-east tower are several faintly engraved ship illustrations. One shows a large Arab ship, its rigging hanging slack, surrounded by groups of numerous small objects possibly representing fish (Fig. 14). Positioned near the top of its rigging are small boats, propelled by oars (Fig. 15a). Is this telling a story? Does it represent a sinking and are these small boats trying to salvage the large vessel? Or is there no spatial relationship implied at all, it being merely just another case of separate unrelated drawings, done over a long period of time and layered one over another? The styles do appear similar, and perhaps are done by the same hand, but further on-site study is required to reach any conclusions.

The passageway leading to the upper level of the fort also displays a ship graffito (Fig. 15b), a large three-masted square-rigged vessel with a banner flying from its stem head. The main course is furled, and a large main top is clearly visible. Shrouds and ratlines, as well as some stays are depicted. A lateen or gaff yard (interpretation is difficult) is fitted on the mizzen mast and the mainmast is fitted with topsail, top gallant and royal sail. On the foredeck is a deck house, and a peculiar design which looks like a sun motif appears above the hull between the fore and mainmasts. A similar motif occurs, twice, on a representation of a *boom* on a cliff face at Kumzar. The hull of the Bayt Al Na'aman ship has the typical 'grab' bow and the long overhanging stern seen in the graffiti at Fulaij and the London Science Museum model. The vessel clearly shows a combination of European rig and Arab hull.

Bahla mosque

In the interior, at the abandoned Bahla Mosque (adjacent to the Bahla fort), incised on one of the columns is a carving of a *boom* (Fig. 16). The image shows a large double-ended trading vessel with one mast (in x-ray section view through the hull) and the sail set. The long straight stem projects well beyond the hull and the stern-post is set at about 15 degrees off the vertical. Although the rudder is usually attached to the stern-post it does not appear in this image. As shown in this example, the outboard end of the prow was often used to tie off the sail.

The *boom* is of particular significance because it is probably the oldest of the traditional Indian Ocean trading vessels. It was the largest of all pre-European Arab craft often up to 36 metres long, with a beam of 10 metres. It typically weighed up to 400 tonnes and carried cargo to China and East Africa. Other examples of *boom* graffiti were found at Liwa fort.

Also at Bahla mosque was an exquisite small incised image of a double ended vessel with high stern, and one mast. This was recorded as a pencil rubbing (Fig. 17). Mainstays and halyards are easily distinguished. Three flags are shown, two flying as if the vessel is sailing to windward, but the third points towards the bow. If sailing to windward all flags would point to aft. The horizontal line that appears across the mid section of the vessel (often seen in graffiti) may indicate a waterline, or possibly may indicate the line at which the anti-fouling starts on the hull. A similar line can been seen in Figure 16.

Liwa

The interior walls of the unrestored coastal fort at Liwa are heavily rendered with ship graffiti. Most of the images are incised, often with one image extending over onto the next. Some lamp-black wash figures are also apparent. A basic plan of the main fortress (Fig. 18), and positions of examples of graffiti mentioned in the text are shown. The main concentrations of imagery were on the first and second floors.

Many examples of square-rigged vessels were apparent (similar examples have been described above) with large and seemingly oversized pennants attached and sails set on up to three masts. Also, examples of ships towing smaller vessels were evident. The towing arrangement is a commonly represented motif, and may indicate normal operating procedure.

Several clear examples of *baghla* and *ghanjah* were recorded with one or two masts and transom counter sterns. The way to distinguish between the two vessel types is by the size of the hull and the characteristic stem heads. Figure 19 (Position B on the fort plan, Fig. 18) shows a two-masted *baghla* with intricate cross hatching and vertical markings in ten horizontal tiers down the hull. It is possible that the markings are used to distinguish hull planks or are an indication of sewn lashings. The small object with similar cross hatching located on the foredeck of the *baghla* could be interpreted as the ship's boat.

A second cruder image (Fig. 19, Position B) of a vessel complete with what has been interpreted as a net full of fish, is located below the aforementioned. Several examples of fishing nets and the catch of the day were found at Liwa fort. These nets have not been seen in the other forts and may indicate the coastal location of Liwa and its position as a once major fishing port. Another interpretation of the 'nets' is also possible, as schematic representations of cargo holds. The well defined sections and different sizes of objects contained contradicts the 'catch of fish' imagery.

Figure 20 (Position F) shows another example of a net cast wide. Other images from Liwa show nets drawn tightly up against the hull as if being drawn onboard the vessel. The vessel shown in the graffito is a single-masted *baghla*. The vertical and horizontal lines on the hull look similar to hull fastening patterns observed when a vessel is far away. The associated image of a human being in this picture displays a child-like quality. This raises the question, again, of who were the artists and what can be assumed from their interpretations of vessels.

Figure 21 (Position M) depicts another *baghla* or *ghanjah* with transom counter stern and the axial rudder clearly rendered. It is two-masted. The characteristic stem head found on the *baghla* is curved with a distinctive bollard-shaped figurehead. At a distance this looks triangular in shape. Another stem-head ornament type that could be applied to the interpretation of this vessel is from the Indian *kutiyya* boat. It is a small rounded carved projection surmounted by a trefoil crest.

The hull of the vessel shown in Figure 21 is marked with lines of circular holes across two rows of planking. The bottom layer may be gun ports, similar to those in Figure 4 above. The top layer could represent lashing holes. Also shown is an anchor, paid out at the bow. It appears to be an admiralty pattern anchor which would help date the vessel to the early 20th century. Other examples of anchor depicted at Liwa fort are the grapnel type, in use as early as the 13th century.

Figure 22 (Position D) is a black wash rendered example of a *battil*. The *battil* is a distinctive looking vessel with a stem-piece carved like a rounded club and a high stern-post which looks like a simplified dog's head. It is double ended, with the stern section of the hull gently sloping upwards to the

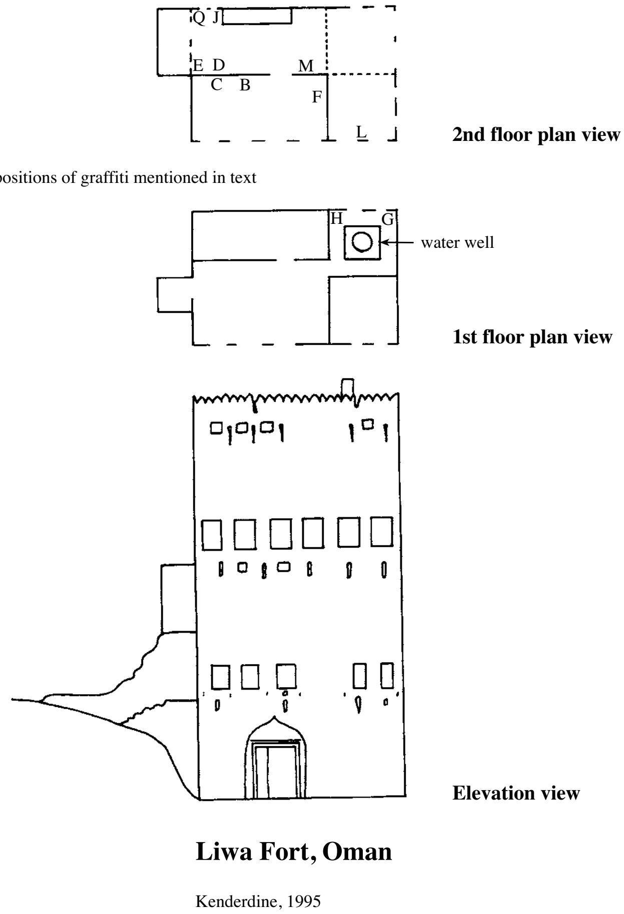

Figure 18. Plan and elevation views of Liwa fort (not to scale).

stern-post. The vessel is depicted with two masts, yards and a rudder attached to the stern-post and extending slightly above the post itself. This rudder is typical of other types of vessels (e.g. Fig. 3) including the *badan* and *zarooqa*. Although it has a high aspect ratio (due to the length that it extends below the hull), it is especially vulnerable in shallow water. In modern examples of this vessel type lines are secured from the lower part of the rudder and are lashed off on the gunwale. The top of the rudder is attached to the stern by a looped rope, and is also partly held in place by the tiller ropes running forward. There are no pintles or gudgeons. It would appear that all these fastenings could easily be let go should a submerged object be encountered.

Figure 23 (Position G) is a three-masted vessel with flags flying at the stern. It is possibly a *baghla* but this is difficult to discern as the stem is not indicated. What is particularly interesting about this example is the net cast from the stern of the vessel. This adds further to the possible representation of fishing motifs.

Figure 24 (Position L) depicts a *badan*. This vessel was used primarily for fishing and coastal cargo-carrying. It has a low straight silhouette, with a shallow draught. Today they are anywhere up to 100 tonnes. Although this image does not display the typical clipper-type bow, the high upswept stern-post which carries the rudder suspended from it, is shown. In this

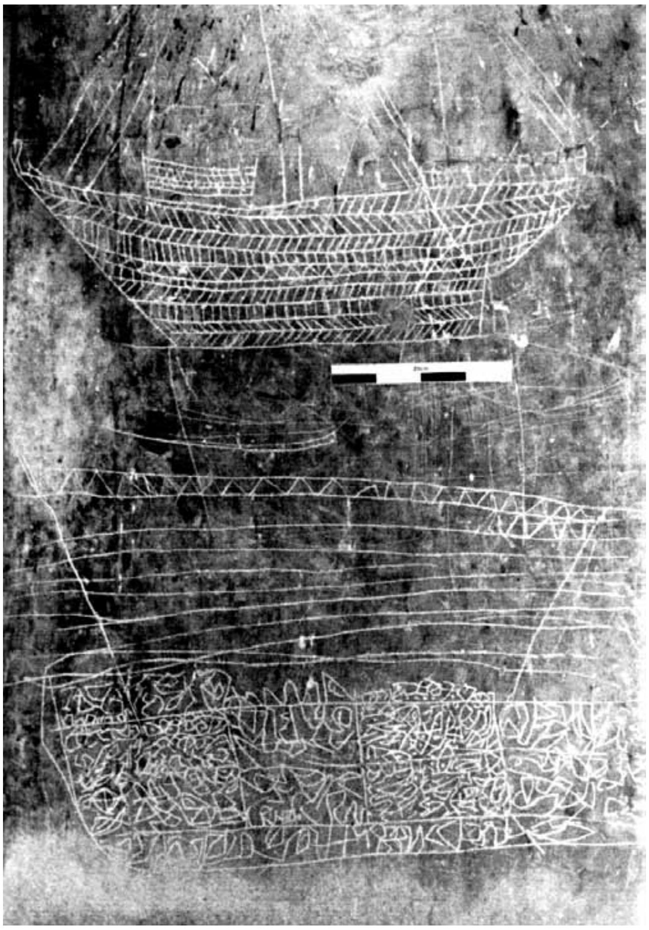

Figure 19. Graffito from Liwa fort, incised illustration of a *baghla*.

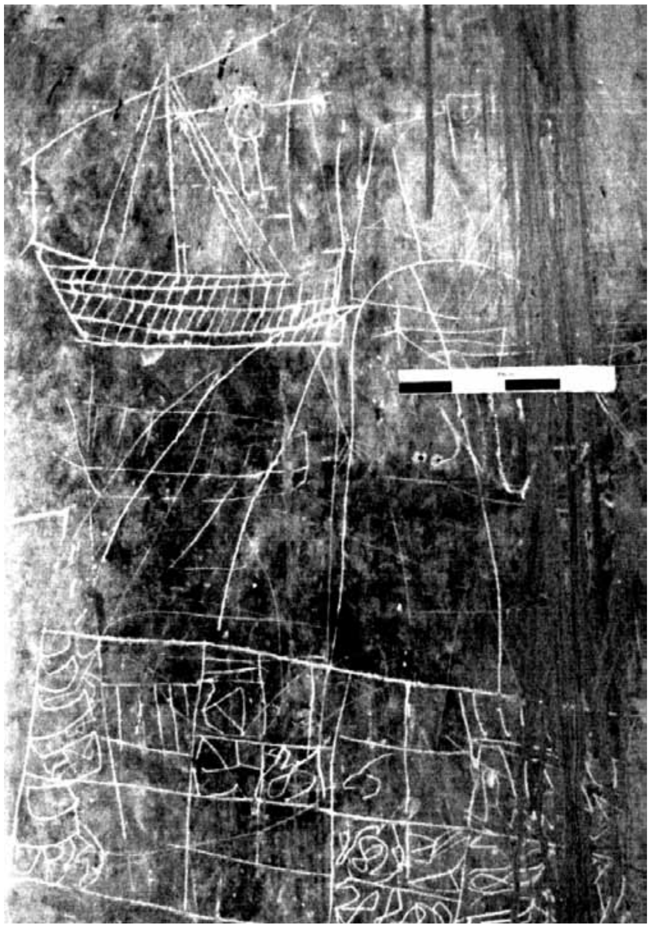

Figure 20. Graffito from Liwa fort, incised illustration of a vessel with net.

example the rudder appears shipped while the admiralty pattern anchor is paid out. In contrast to the 'at anchor' suggestion that this may imply, the Arab or *settee* sail is set. All rigging is shown. A trim of small triangle sections hangs across the sail top, below the yard. A vessel displaying this trim is shown in the engraving by the artist William Daniell dating to his visit to Muscat in 1793 (appearing in the *Oriental Annual* vol. III, 1836 and reproduced in Facey, 1979: 83). While the trim looks decorative it may have had some useful function of which we are not aware.

Figure 25 (Position E) and Figure 26 (Position Q) are examples of the *badan* stern. Position E graffito possibly shows a net attached, while the clipper-type bow is shown in the Position Q example.

Rock graffiti

Kumzar rock graffiti

The two-masted *boom* (Fig. 27) painted on the cliff face just east of Kumzar (mentioned above) is locally believed to be about 50 years old. It exhibits the peculiar x-ray view of the interior of the ship, the mainmast seen extending to the keel. The vertical lines on the hull around the mast may represent the 'mast cage', an enclosure built around the mast below deck, presumably to keep stacked cargo clear of the mast and bailing well. There are horizontal lines on the hull as well, but no interpretation has been made of what they represent. The 'sun' motif occurs twice, but its meaning is also a mystery.

As mentioned earlier, all of these graffiti delineate vessels in profile and in most cultures this appears to be the preferred view. There are however rock art illustrations at Jabal Al-Jussasiyah in north-east Qatar dating from perhaps as early as the tenth century which show vessels in plan view (Facey, 1987). This is probably due to the fact that they are carved on top of a bluff high over the sea, where the artists' view of these boats, gathering for the pearling grounds, would have been from above. They are double-ended and appear to have steering oars. They may predate the introduction of the axial rudder, thought to have occurred during the thirteenth century. The boats display a shape and arrangement of beams which are very similar to those of boats in Musandam today. But even amongst these petroglyphs are some—of less primitive design and probably of later date—shown in profile, depicting classic *battil* and *baggarah* in fine detail. One shows a stern profile and decorations virtually identical to those seen on *battil* at Kumzar in Musandam, and similar to the Fulaij fort representation of a *battil*.

Khawr khayran

The cliffs of Khawr Khayran as well as Khawr Kumzar in Musandam display numerous graffiti, which although painted

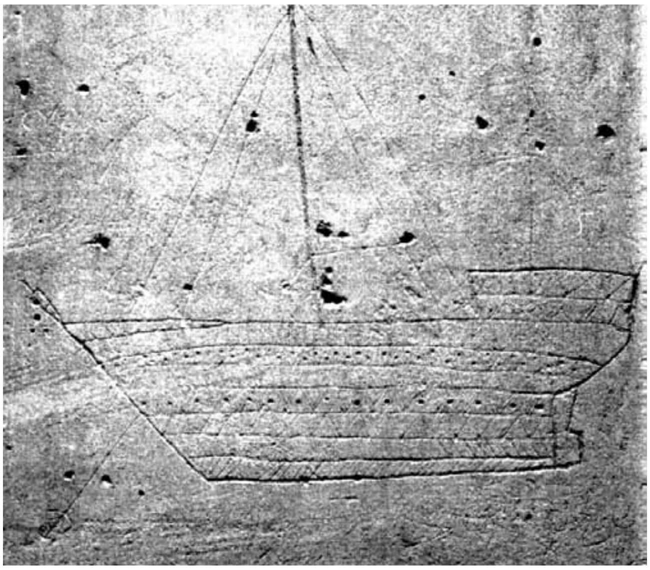

Figure 21. Graffito from Liwa fort, incised illustration of a two-masted *baghla* or *ghanjah*.

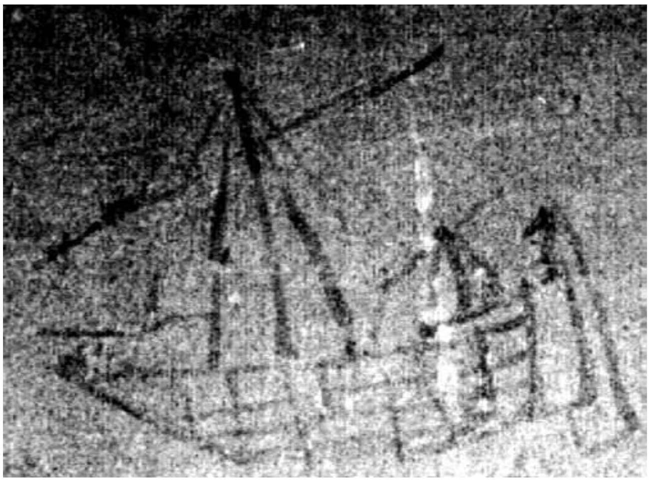

Figure 22. Graffito from Liwa fort, lamp-black wash illustration of a *battil*.

Figure 23. Graffito from Liwa fort, incised illustration of a *baghla*.

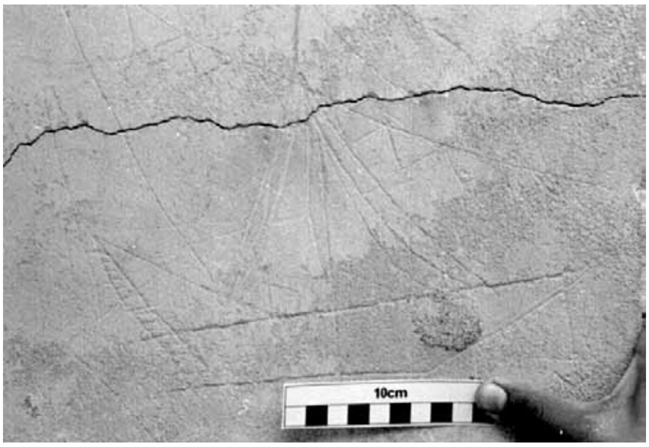

Figure 24. Graffito from Liwa fort, incised illustration of a *badan*.

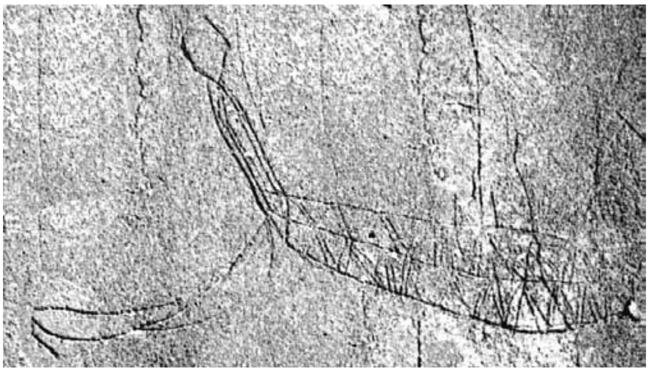

Figure 25. Graffito from Liwa fort, incised illustration of a *badan* stern.

Figure 26. Graffito from Liwa fort, incised illustration of a *badan*.

and relatively modern, are still interesting. Several are clearly motorised vessels, but others have masts and yards. Like the Kumzar cliff paining of a *boom* and many of the fort graffiti they use the convention of depicting the mast extending to the keel, as in ‘x-ray’ view (Fig. 28). These recent graffiti come from two sources: Musandam fishermen who visit these inlets and use the small coves to set up base camps, and Iranian traders running between Khasab in Musandam or Dubai and their contacts in Iran. The best way to learn how to interpret the motifs of the drawings would be to interview some of these people about the graffiti, but a difficulty arises in locating the people who have done them. If they could be found, their information might explain some of the similar conventions used in older graffiti.

Wadi Fara'

The coastal plain of the Batinah coast of Oman is backed by an imposing range of mountains, Al Hajar al Gharbi, stretching from Muscat to Musandam. Some 60 kilometres from the sea is the tallest of the mountains, the Jebel Akhdar (Green Mountain) and pecked into a rock face at Wadi Fara' in the Jebel Akhdar is another ship (Clarke, 1975). It is three-masted, square-rigged, with a large stern castle and a tall slim structure that may be a smoke stack from a steam engine. The ship may be an auxiliary steamship of the mid-nineteenth century. The form of the hull resembles ships from this era, but the rig is difficult to interpret. Shrouds, stays and braces for the yards are depicted and again royal yards appear to be present, if not on the foremast, then certainly on the main. A spanker yard is clearly evident on the mizzen mast. It is curious to find a ship representation so far from the sea, but does demonstrate the cultural or trading links between interior Oman and the coastal settlements and seafaring people.

Wadi Bani Kharus

This wadi cuts deep into the rock strata of the Jebel Akhdar. The youngest rocks at the entrance are rich in small fossils. About 2 kilometres up the wadi there is a massive vertical cliff full of a variety of gastropods and bivalves. The rock is also covered with many drawings of animals and warriors on horses. Several examples of ships have also been hand pecked into the rock. Recent archaeological analysis of them suggests that some of these images are 1 500 years old (Klein & Brickson, 1992: 37).

Other sites

Qalhat

The town of Qalhat, destroyed by an earthquake and an attack by the Portuguese in the early 16th century, had been a thriving maritime entrepôt from at least early Islamic times. From the ruins it is evident that the buildings were constructed of rocks bound together with mud mortar. Amongst the rubble of the town, only a ruined mosque and sections of a few small structures survive. In one of the tiny domed structures to the east of the town were found graffiti of Arab ships, incised into the plaster-rendered interior. Most of the graffiti are so faint as to be impossible to interpret, but one displayed an Arab vessel lying at anchor (Fig. 29). The yard has been lowered, but the shrouds and halyards are clearly evident, and flags fly from the masthead and the stern. The form of the bow is impossible to discern, but the stern has an enormous stern castle. The sea is visible from the structure, so this graffito might record a visit from a specific ship, observed lying at anchor to a northerly wind (*shamal*).

Graffiti culture and iconography

The complex of graffiti, from stylised and child-like renditions to elaborate and accurate examples of vessel types, forces an examination of the possible artists of these drawings. Some of the questions raised by studying the imagery include:

- what was the impetus behind ship graffiti?
- why does ship graffiti appear in some forts and not others?

Figure 27. Painting of a *boom* on a cliff face at Khawr Kumzar, Musandam.

Figure 28. Painting of a two-masted vessel with bowsprit at Khawr Khayran, Musandam.

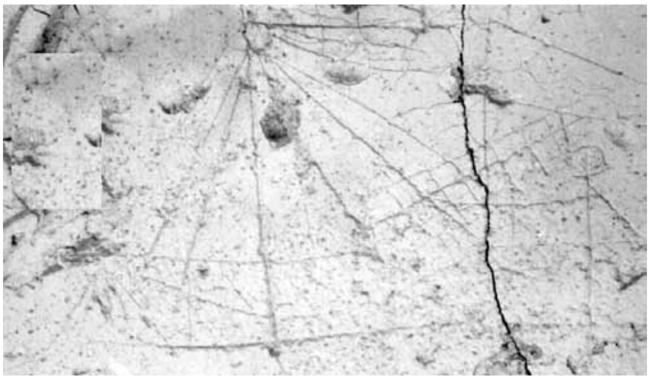

Figure 29. Graffito from Qalhat.

- was permission necessary to undertake the drawings or, as is the case today in Western culture, were they undertaken in defiance of authority?
- what other forms of enterprise are depicted in graffiti (such as date farms or the falaj systems, and so on)?
- what can be learned from associated text and imagery?

The comparative analysis of the Oman graffiti reveals that certain aspects of rigging, construction and equipment are discernible across a number of geographically separate sites. We can assume then that the illustrations are based on realistic and knowledgeable representations (Nicolle, 1989: 168) and are not fantastic. Some vessel types occur more frequently than others but because of the nature of the archaeological record (i.e. with much graffiti destroyed through restoration) it is not possible to interpret this as a reflection of the predominance of certain ship types in Omani waters between the 16th and 20th century. It is, however, possible to consider the proportional analysis of vessel types represented within a single fort. Liwa fort because it is unrestored and has such a wealth of imagery could be a good site for this sort of investigation.

One informant (at Liwa fort) suggested that the impetus behind the graffiti was as a record of vessel types visiting the port, and that the name of the ship, date of arrival and departure, and possibly the nature of the cargo were also recorded. However, little evidence of Arabic scripts were found in conjunction with the graffiti to substantiate this.

At other sites text has been found in conjunction with the drawings. There is writing on the walls at Fulaij, some Arabic, Hindi or Urdu texts exist that indicate links with other centres.

Ship graffiti is often found in conjunction with other subjects represented. Horses, camels, mounted riders, forts, palm trees and human figures are common. Hazm, Liwa, and Nizwa forts were especially rich in these.

Obviously it is difficult to estimate the amount of graffiti lost due to restoration. The unrestored forts display different construction materials and design. Some, more obviously, are able to support imagery better than others. Mud brick walls that had not been plastered over in some manner tend to be crumbly and unsuitable for engraving and wash.

The question of official sanction for graffiti may be displayed in those renderings that are elaborate and complex. The cruder and child-like images are obviously quick scratchings. As recording of the graffiti took place, local children attracted by the activity were quick to display their own skills as illustrators.

The possible age of the graffiti varies, many of the earlier images partially obscured by subsequent drawings. From the types of vessel designs depicted they are thought to date from the mid-17th century to the 20th century.

Conclusions and recommendations

Most of the forts and many merchants' homes in Oman have been restored or are undergoing restoration. In many cases, the graffiti have been preserved, but in others, examination has shown that graffiti were destroyed by over plastering or destruction of the walls. In some cases, rebuilding of walls was inevitable. However, prior to their destruction, attempts to record the graffiti images should have been made. This could have been done photographically or by casting a mould of the graffiti in dental rubber. It is not too late for the remaining examples. Photography or video with film sensitive to different wavelengths of light or computer enhancement could make interpretation of the drawings easier. To make interpretation more meaningful, additional research needs to be done in dating the drawings and graffiti. Transcription, translation and comparison of the text needs to be undertaken.

These graffiti can expand on the nautical graffiti in Qatar reported by Kapel (Facey, 1987), Garlake (1964) in East Africa and the general compendium of shipping in Islamic art compiled by Nicolle (1989). Despite the problems of damage to the graffiti, the sometimes crude or unskilled rendering, and the difficulties inherent in interpreting works from a foreign culture and different time, the Omani graffiti are a valuable source of information about shipping, foreign contacts and trade in Omani waters. On another level they are an integral physical part of the maritime heritage of the nation, and all efforts should be made to preserve and document them.

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Without the support of a large number of individuals and organisations, none of the research in Oman over the past years would have been possible. The authors wish to thank Earthwatch and its EarthCorps group of volunteers for their contributions and participation. We would also like to acknowledge the generous support of the Royal Navy of Oman, the Ministry of National Heritage and Culture, the General Electric and Trading Company (Oman), Holiday Inn Salalah, Seeb Novotel, and Khimji Ramdas. Thanks are extended to the Western Australian Maritime Museum, the Indian Ocean Centre for Peace Studies, the Australian Research Council and Kodak (Australasia).

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Contents