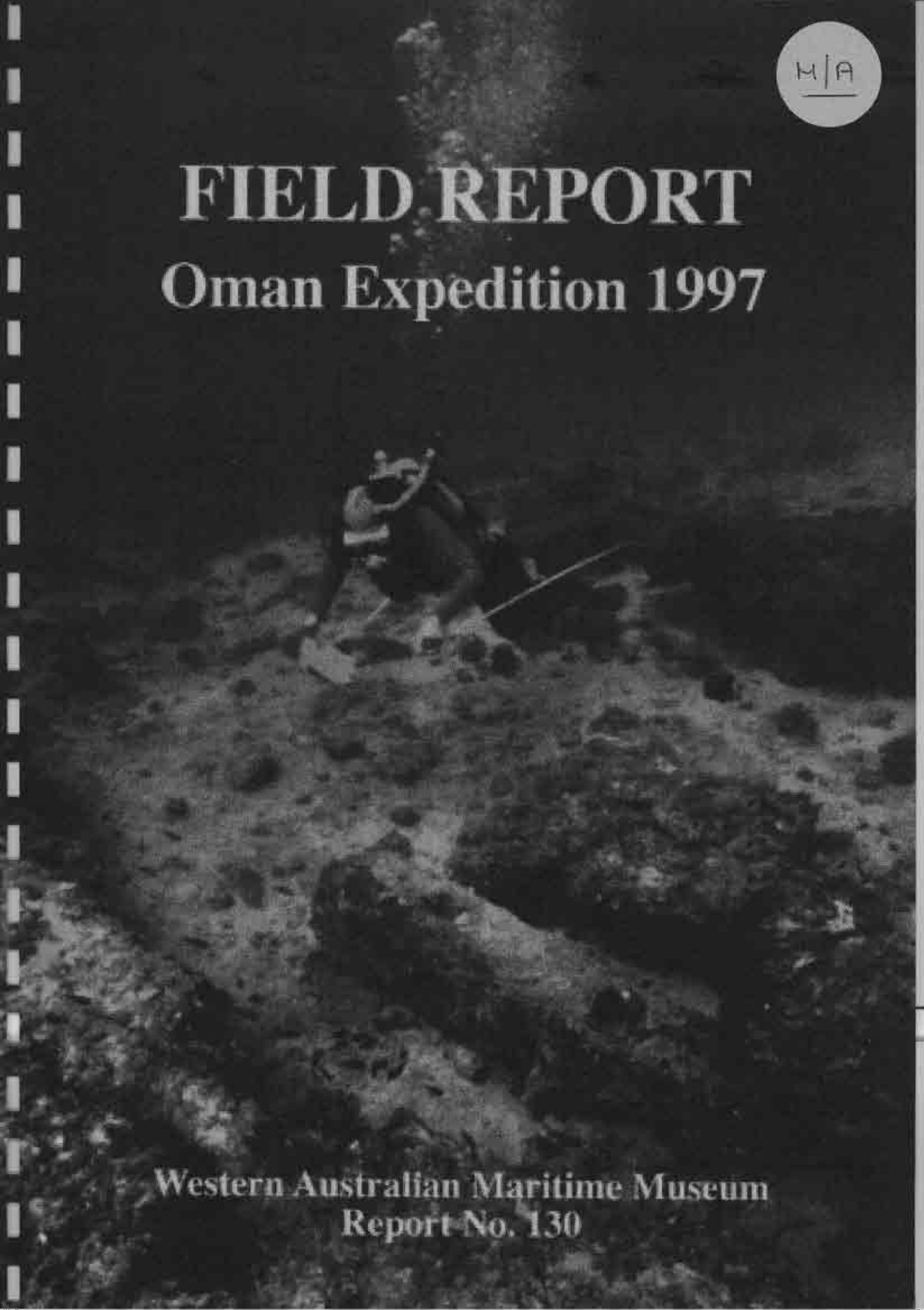
FIELD REPORT
Oman Expedition 1997



Western Australian Maritime Museum
Report No. 130

FIELD REPORT
Oman Expedition 1997

Tom Vosmer
Patrick Baker
Jon Carpenter
Western Australian Maritime Museum
Report No. 130

ACKNOWLEDGMENTS

The project is indebted to His Majesty Sultan Qaboos bin Said and to the Royal Navy of Oman, particularly His Highness Shihab bin Tarik bin Taimur Al Said, Commander of the Royal Navy of Oman. We are very grateful for the comprehensive support provided by the Diving Group of the RNO, it's officers and men, and for the support of Lima 8, *Saba Al Bahr*. The project is very grateful to the Ministry of National Heritage and Culture, particularly Dr Ali Ahmed Bakhit Al-Shanfari, Director of Antiquities, and to the Joint Hadd Project for the use of the Project compound at Ra's Al Jinz.

We also wish to acknowledge the generous support of Earthwatch and its Research Corps of volunteers who contributed both financially and personally to the expedition. Thanks also to Desert Line Projects LLC, Gulf Petrochemical Services, Petroleum Development Oman, Oman National Dairy, Amiantit Oman SOAC, Khimji Ramdas, Fugro Survey Dubai, Mike and Amanda Morwood, Imshi and Alan Burrell, and to the BSAC divers from Sharjah and Muscat. Special thanks are due Omzest for its very welcome support.

And finally grateful thanks to our staff from the Western Australian Maritime Museum who contributed their time, hard work, experience and finance to the expedition.

TABLE OF CONTENTS

Acknowledgments i

Illustrations iii

Aims and Objectives 1

Dive Times 2

Team 1 (Khawr al Jaramah, Ghalilah, Qalhat) 2

Significance of finds 7

Conservation of the artefacts 9

Team 2 (Musandam) 10

Summary of Musandam Sector Diving 11

Recovered artefacts 14
- RAJ1 (Stone anchor shank) 14
- SHI1 (Stone anchor shank) 14
- SHI2 (Ringstone) 15
- GHA1 (Stone anchor shank) 16
- GHA2 (Stone anchor shank) 16
- QAL1 (Ringstone) 17
- QAL2 (Grindstone or rotary quern) 17
- DIB1 (Stone anchor shank) 18

Recommendations 19

Appendix A 20
- Personnel 20
- Equipment 20
- Abbreviations 21

Appendix B. Conservation of maritime archaeological artefacts 22

Bibliography 24

ILLUSTRATIONS

1. Map of the Ja'lan region, showing Khawr al Jaramah and Ra's al Jinz. 1
2. Detail of the mouth of Khawr al Jaramah, showing survey paths. 2
3. Map of Ghalilah and Qalhat region. 3
4. Stone anchor shank GHA1 on the seabed. 4
5. Diagram of the spatial relationship of the anchors GHA1 and GHA2. 5
6. Stone anchor shank GHA1 with lifting bag attached. 5
7. A diver with the ringstone QAL1. 6
8. The rotary quern. 6
9 The single-hole anchor. 6
10. Large stone anchor in situ. 6
11. Dressed architectural stone. 7
12. Model stone anchor, with stock and two arms. 7
13. Variations on stone anchors. 8
14. Map of northern Musandam peninsula. 10
15. Bottom of bottle with Maltese Cross imprint. 13
16. Drawing of stone anchor from Ra's al Jinz. 14
17. Fisherman with stone anchor shank RAJ 1 near Ra's al Jinz. 14
18. Limestone anchor shank SHI 1 from Shiya. 15
19. Ringstones from a. A'Sulayb (now at A'Seelah) and b. Shiya. 15
20. Stone anchor shank GHA 1. 16
21.GHA1 after cleaning. 16
22. Anchor shank GHA 2. 16
23. Stone anchor shank GHA2 before cleaning. 16
24. Ringstone QAL1 after cleaning. 17
25. Drawing of ringstone QAL 1. 17
26. One method of using a ringstone as a 'mushroom' anchor. 17
27. Top of rotary quern. 18
28. Underside of rotary quern. 18
29. Large stone anchor shank from Dibba.28. DIB drawing. 18
30. Drawing of stone anchor shank DIB 1. 18
31. Removing accretion from stone anchor shank GHA1 by mechanical means. 22

FIELD REPORT OMAN 1997

From 28 February through 30 March, 1997, personnel from the Department of Maritime Archaeology of the Western Australian Maritime museum, the Royal Navy of Oman, and volunteers from Earthwatch, BSAC 406 and Muscat divers conducted a fifth archaeological/ethnographic expedition to the Sultanate of Oman.

Aims and Objectives

The primary aims of the expedition were to search for and, in the event of discovery, survey and record any artefacts relating to the ancient maritime culture of Oman. A secondary objective was to recover significant finds to investigate their provenance and dating, or to rescue those artefacts threatened by development or looting.

Search Areas

The areas on which the project chose to focus were Khawr al Jaramah, the coast to the west of Khawr al Jaramah, Ghalilah, Qalhat, and various locations in Musandam (Figures 1, 2, 3 and 14).

In the region around Khawr al Jaramah are more than fifty known archaeological sites, ranging in date from the Holocene to recent times. The khawr itself is a very sheltered anchorage and would have been an ideal place for ancient ships to have moored. However, the entrance to the khawr is narrow and bordered by rocky shores, making it a place where shipwrecks may have occurred.

The coast between Sur and Qalhat (which includes the village of Ghalilah) has been a busy shipping lane for centuries, and of course Qalhat itself is a well-known and important early Islamic and medieval port. The massive maritime activity over the centuries has surely left many maritime artefacts in the coastal waters.

The Musandam region has figured prominently in Arabian Gulf voyaging since mankind took to the sea. Its tall mountains offered landmarks, its deep narrow khawrs provided shelter, its sheer coastal cliffs and swift currents threatened to wreck unwary or unlucky sailors. The region is also rich in terrestrial archaeological sites. These

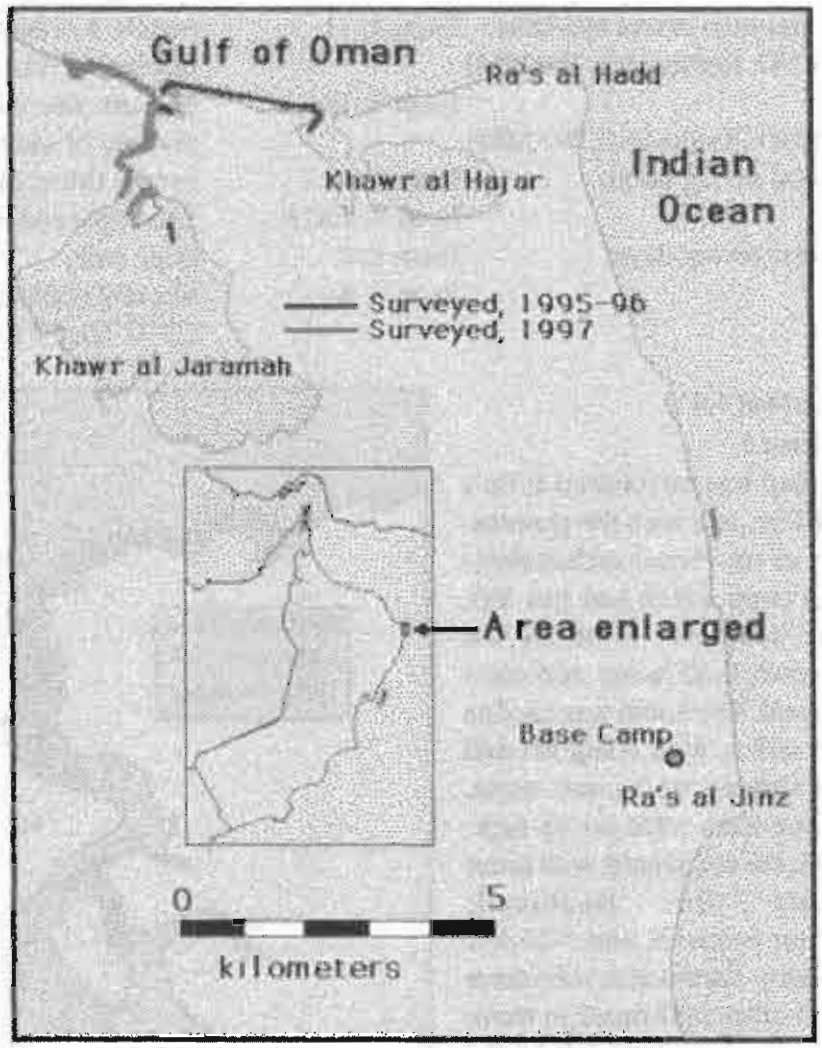


Figure 1. Map of the Ja'lan region, showing Khawr al Jaramah, and Ra's al Jinz.

factors combine to make it an attractive area for maritime archaeological survey.

Dive Times

The time apportioned to diving was governed to a large degree by the weather, the time needed to reach dive sites from base camp and the number of divers available. It should be remembered that due to logistic and safety issues, all the available divers could never be deployed at once.

Maximum divers available: (RNO, Earthwatch, WAMM)	Team 1: 11
	Team 2: 18 (RNO, Earthwatch, WAMM)
Total diving hours:	Team 1: 48.4
	Team 2: 100.8
Total diving days:	Team 1: 8
	Team 2: 8

SUMMARY

Team 1

Camp was established at Ra's al Jinz, and with the generosity of the French archaeological team which had just left, we were able to utilise the French field house and compound. The house was used as an office, with computer and printer set up in one room. Navy tents were set up adjacent the compound, with small tents for Nankivell, Honeychurch and Vosmer nearby. Earthwatch volunteers and other staff opted to move into the large tents left by the French team within the compound walls.

The primary objective of Team 1 was to resume and extend the searches initiated during the 1995-96 expedition (Vosmer 1996). Nearly the entire length of the entrance channel to Khawr Al Jaramah was searched, some by swim line and some by depth contour searches. The head of the island was also searched (Figure 2).

Modern artefacts and a few older (perhaps 19th century) were discovered in the channel (Figure 2). A large iron four-arm grapnel anchor (KAJ 1) was discovered in approximately 10 metres of water at a position of 22°31'41N, 59°43'55 (position by GPS). The shank measured approximately 1.5 metres in length, the arms spanned one metre. When the anchor was discovered only one arm was showing above the sand and hand-fanning of sand and sediment was necessary to expose the anchor in order to record the its size. The upper end of the shank was jammed under a large rock.

Slightly north and to the east, close to the shore, 22°31'50, 59°44'01 (GPS) one arm of an iden-

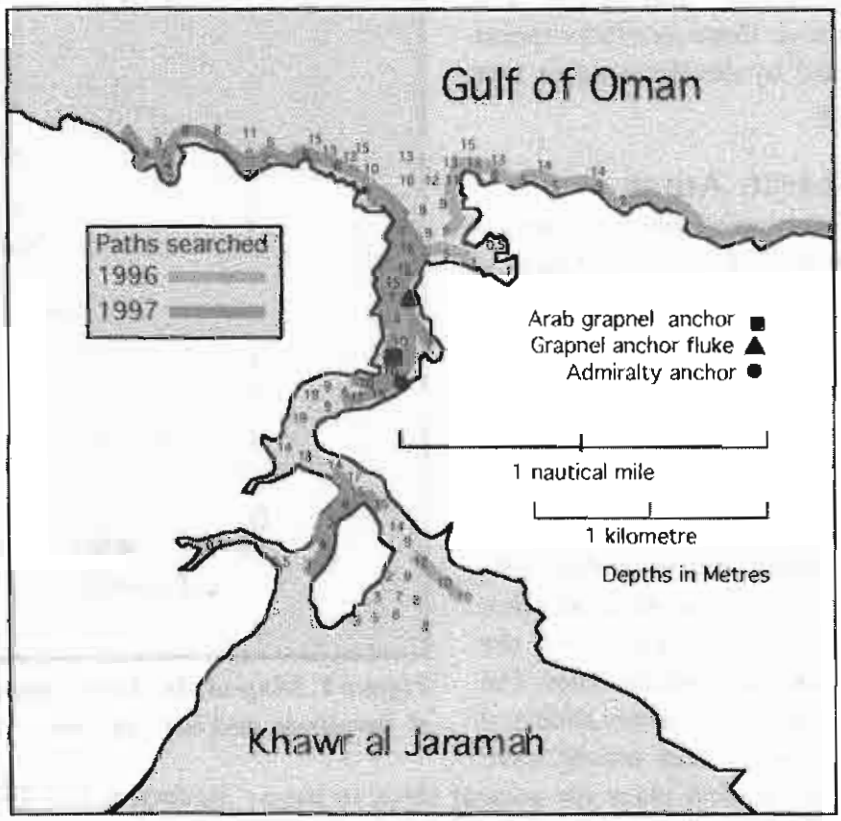


Figure 2. Detail of the mouth of Khawr al Jaramah, showing survey paths.

tical anchor was located (KAJ 2). It was recovered for teaching purposes, in order to show the less experienced people what sort of things to look for, and to explain the formation and appearance of marine concretion on iron objects.

At the position 22°31'38, 59°43'56 (GPS) a medium-size Admiralty anchor (KAJ 3) with a broken sliding stock was discovered. No anchor chain was present. As European vessels would almost certainly have used chain, its absence may indicate that this anchor was being used from an Arab or Indian vessel.

Due to the lack of iron conservation facilities and the recent date of the artefacts the decision was taken not to recover either of the iron anchors. No older artefacts were discovered during the searches.

The coastline west of KAJ was searched on depth contours to 18 metres maximum for a distance of 0.5 km. Nothing but modern debris such as fishing nets, discarded containers of various kinds, fishing weights, abandoned fish traps, etc. was found.

On 6 March we had a rendezvous with Ken and Dot Gorman near the abandoned fish farm north-west of Sur. Ken and Dot were to show us the site where two Arabo-Indian stone anchor shanks, a 'Mediterranean' stone anchor, cannon, and a ringstone had been discovered in the late 1980s by members of the Muscat British Sub-Aqua Club. Unfortunately, the ringstone, cannon and 'Mediterranean' anchor had disappeared, but the stone shanks were still *in situ* about ten metres apart at position 22°39'50, 59°24'49, five and one half kilometres south-east of Qalhat. Both were at a depth of about 15 metres, less than 500 metres offshore. One (designated GHA 1) lay in a north-south orientation with the large end north (Figure 4). It was proud of the sand/shell bottom alongside a small low reef. GHA 1 was marked with a surface marker buoy (SMB). The other (designated GHA 2) was orientated at 112°, with the narrow end to the east. It was partially lying under a low reef, in a narrow space between that reef and a higher reef to the south.

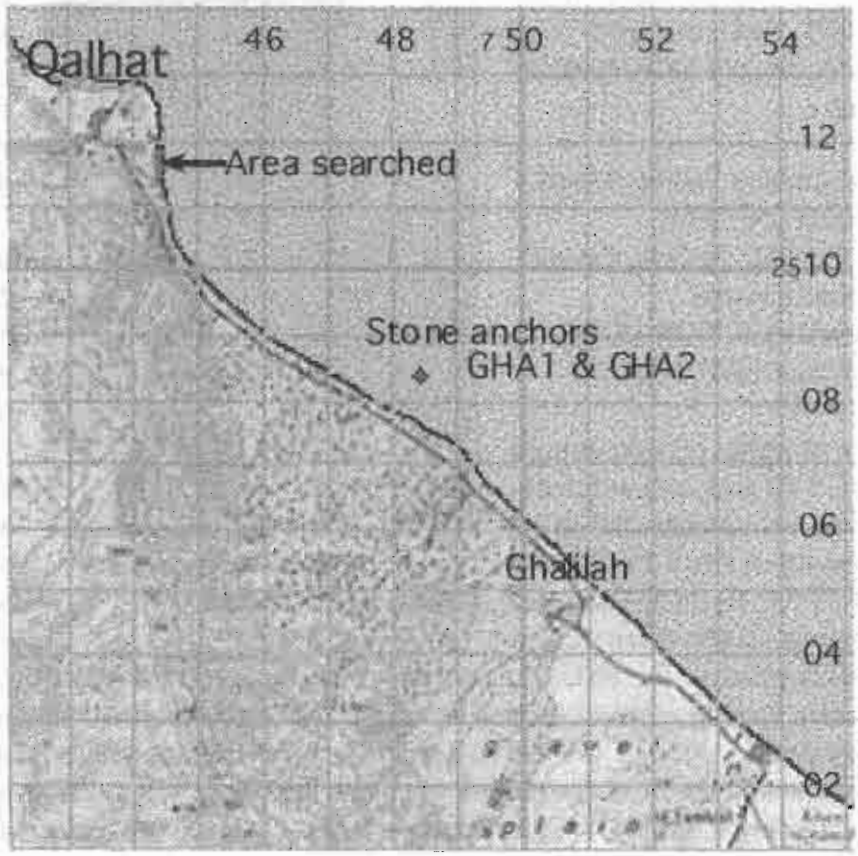


Figure 3. Map of Ghalilah and Qalhat region, showing position of Ghalilah anchors and area searched at Qalhat.

These reefs are frequently destroyed by winter storms, but quickly rebuild (personal communication, A. Kiyumi, 1997). This might explain why the second anchor was under a reef (where it could not have fallen originally, had its wooden arms been in place).

This underwater site is near a liquid natural gas (LNG) complex development and the artefacts

were judged to be under threat from the dredging and pier-building operations of the LNG plant development. It was decided to recover both the shanks. Labelled control points (steel reinforcing rods) were driven into the bottom alongside a nearby reef and the distance to key points on each anchor were measured from each of them (Figure 5). The position and orientation of each anchor shank, and their mutual spatial relationship were thus carefully recorded. Meanwhile, the position of the SMB was surveyed from land, the key benchmark being:

Benchmark Station BM 02
Oman LNG LLC
UTM PSD 93 Grid, Coordinates in metres
Northing Y 2507657.125
Easting X 747583.571

For mapping we were using a WGS 84 grid, so the Benchmark coordinates had to be converted from PSD 93 to WGS 84. To do this, the following standard correction was applied to the PSD 93 position: -290.13 metres Easting, -249.12 metres Northing. This calculation yielded a WGS 84 position for Benchmark BM 02 of Northing Y 2507408.005 and Easting X 747293.441. Attempts were made to survey bearings from this point and other selected benchmark positions, but unfortunately insufficient distance data among points were recorded to enable effective use of the bearing information.

Figure 4. Stone anchor shank GHA1 on the seabed

However, the position of the SMB over the stone anchors was recorded by GPS as 22°39'50, 59°24'49, and documented with photo transits.

Underwater, systematic searches were conducted in the immediate area in the hope of discovering additional artefacts. From the bearings on which the anchors lay, the direction the vessel had been moving was also approximated, and the area in this direction searched for additional artefacts. However, nothing of further interest was encountered.

GHA 1 was carefully freed from the bottom and a 500 kg lifting bag attached (Figure 6). The weight of the anchor shank had been estimated at 235 kg. A surface marker buoy (SMB) was attached to the anchor shank in the event that the shank slipped from its straps during the lift or transfer to the shore. A successful lift brought the anchor to within 2 metres of the surface, for the first time in several hundred years. The entire process was recorded on video and photographed. The anchor shank, suspended below its lifting bag, was then towed by rubber boat to a barge crane about one mile away. The intention was to lift the anchor shank from the water by crane and place it in one of the rubber boats for transfer to the shore. Permission to use the crane had been obtained the previous day from the crane operators. However, the crane was not operating at the time, so we went back to lift the second anchor shank.

After it was freed from the bottom, this anchor shank too was successfully lifted and towed to the barge. Although the anchor was estimated to weigh only about 265 kilograms, a 1000kg lift bag was used, as the other available lifting equipment comprised only two 100kg bags.

The crane was still not in operation, but a drilling rig with lifting capacity aboard the barge was

employed to lift both anchor shanks into one rubber boat. We are grateful to the Fugro Survey Dubai , and particularly Mr Gerry McBride, and to Archirodon, for allowing the rig to be used for this purpose.

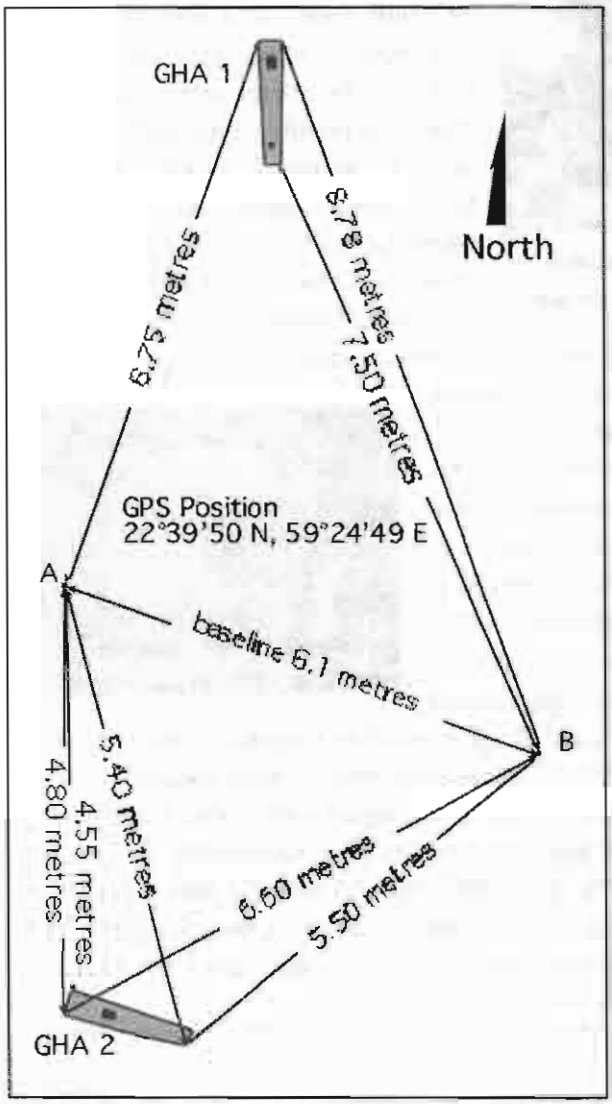


Figure 5. Diagram of the spatial re;lationship of the anchors GHA1 and GHA2

The boat was driven to the shore where the shanks were lifted by hydraulic crane into the expedition's 10-ton truck for transport to the base camp at Ra's Al Jinz. The truck bed had been prepared with sandbags, plastic sheeting and wet hessian in order to cushion and wrap the shanks and keep them wet.

At the base camp they were unloaded and set up on a bed of concrete blocks and sandbags to be de-concreted. De-concreting by light percussion with geologic hammers and chisels (not used with a hammer or mallet) was demonstrated by Jon Carpenter after which several Earthwatch volunteers and staff launched into the task on one anchor. One of the volunteers had some geological training and determined that the rock from which the anchor shank was made was dark grey basaltic stone. This was later confirmed by a geologist, Dr Ingeborg Guba, from Sultan Qaboos University.

Figure 6. Stone anchor shank GHA1 with lifting bag attached.

On 9 March a reconnaissance was made along the coast north of Sur to seek locations that might be promising for wrecks or artefacts. It was determined that the coast south of Qalhat might be a fruitful location and on 10 March diving operations commenced near the ruins of the ancient city (Figure 3).

Qalhat was chosen for two reasons: its importance as a pre- and early Islamic port, and the fact that a semi-exposed roadstead for the anchoring of ancient ships might not have acquired a very deep covering of silt and sand.

There are two marine areas near the port city where maritime evidence is likely to be found. One is the mouth of the Wadi Hilm north of the ruins, where ships in ancient times could probably have gained good shelter. The other is the roadstead to the east of the ruins, just off shore.

Though sheltered only from westerly and north-westerly winds (such as the shamal) this site would have been useful as a convenient anchorage. It is bordered on the north by the spit of land extending from Wadi Hilm and on the south by the ancient city wall and a deep underwater wadi (an extension of the small wadi to the south of the city wall).

Figure 7. A diver with the ringstone.

Qalhat is known to have been in existence since at least the second century AD, when Azd people led by the legendary Malik bin Fahm are believed to have settled there. Much of Oman was at the time under the control of Persia. Later Qalhat served as a sister port of great importance to Hormuz during the Hormuzi period. Qalhat was still an important port when Marco Polo visited in the 13th century and Ibn Batutta in the 14th century. By the time the Portuguese arrived in the early 16th century Qalhat had begun to decline, eclipsed by the rise of Sur and Muscat.

Figure 8. A diver with the rotary quern.

Qalhat Maritime Survey

Initially, it was decided to make a swim-line search of the seabed near the shore commencing at the northern tip of the bay, south of Wadi Hilm. Six divers were put in the water, but as the search progressed they were swept off shore by the current, bringing them away from their assigned depth contours. The swim-line search was abandoned and all divers made their way back to the beach on the surface. Unfortunately, the outboard engines on both rubber boats deployed at the time developed mechanical problems and could not be used to pick up the divers. While four divers helped with the mechanical problems of the boats the search was resumed by two divers working along the shore. The seabed was found to be sand, with low reefs and a scatter of small rocks. In a section of the bay close to shore near the northern end the rocks were often arranged in parallel rows, and formed angular geometric blocks. Due to their regular shapes, these could at times be mistaken for man-made objects. After a short while a ringstone (Figure 7) was discovered by Mulazim Juma in about four metres depth. This was quickly followed by the discovery of numerous whole and broken anchor shanks, a grindstone (Figure 8), a single-hole stone anchor (Figure 9) and another ringstone. Altogether some 20 large stone objects were located. Positions for all were logged with photo transits of the shore, by survey from the beach, and with GPS. All of the objects had but a thin encrustation of marine growth and it is thought they had probably been recently uncovered by winter storms.

Figure 9. The single-hole anchor.

Figure 10. Large stone anchor in situ.

It was later discovered that the GPS, like the outboard engines, was not functioning properly

Figure 11.
Dressed architectural stone.

and most of these readings were erroneous. The GPS and outboards were not the only equipment to malfunction, as both the video cameras succumbed, along with an underwater stills camera. But that was not the end of the trouble. Over the two and a half days spent on the site one of the divers was stung by a scorpion, one of our 4WD vehicles was hit by another vehicle and rendered unserviceable, one of the 10-tonne trucks broke down and the other sustained a broken windscreen.

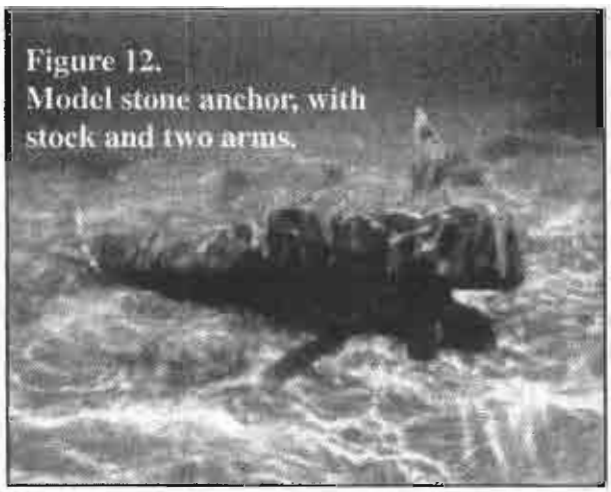


Figure 12.
Model stone anchor, with stock and two arms.

Through all of this, however, the site yielded significant discoveries. On 11 March the first-discovered ringstone was recovered, and on 12 March the grindstone was brought up. Both were carefully wrapped in wet hessian and plastic sheeting for transportation to Said bin Sultan Naval Base. On 12 March a very large stone anchor (Figure 10) was discovered in shallow water within two metres of the beach, as was a dressed architectural stone (Figure 11). No similar dressed stones were seen among the ruins of Qalhat. Possible explanations are: 1. This one is a unique import, 2. Other similar blocks were taken from Qalhat for building elsewhere, 3. Similar stones may lie hidden under the unexcavated ruins of Qalhat. The stone may be Portuguese, as they imported building stone from East Africa.

The expedition broke camp on 12 March and returned to Muscat in order to prepare for the second phase of the expedition scheduled for Musandam.

Significance of finds

In regard to the stone anchors, the significance lies in their number, their sizes and shapes, where they are broken, and their provenance. Prior to these discoveries there were perhaps two dozen stone anchors of the Arabo-Indian type catalogued in the Indian Ocean and Red Sea (Chittick 1980, Kapitän 1994, Owen 1995, Raban 1990, Whitehouse 1970). The fact that the stone anchors were found off Qalhat in such quantities (the greatest underwater concentration reported to date) may provide more accurate dating for the corpus. Twenty-four of similar type have recently been reported from India, but all were being re-used as architectural elements in dock works, forts, or as erosion controls (Tripati 1997). The discovery of about twelve additional anchors or anchor fragments off Qalhat increases the corpus of finds and expands the database for research.

It may be no coincidence that similar anchors have been found at Kilwa on the East African coast and at Siraf in Iran, both ports broadly contemporary with Qalhat.

Morphometric analyses can be done on the entire body of anchors and comparisons made among them. The damage sustained by the broken anchors may provide clues to the way they were used and may suggest what the composite

stone/wood configuration was. That is, from these newest finds we may expect more deductive answers to whether these were four-arm grapnel anchors, or fitted with two arms and a stock (Figures 12 and 13 c, d and e).

Many questions regarding the configuration of the wood/stone composite anchors need to be examined. For example, if a stock was fitted, in which of the rectangular holes was it? How was the anchor cable attached to the shank? Was it tied directly through the round hole (Figure 13 a, b, c, and d), or perhaps seized around a wooden or metal bar inserted through the hole? (Figure 13 e). How long would the arms and the stock have been, proportional to the anchor? How were the wooden components held in place? Were the arms curved or straight? (Figure 13 a and b).

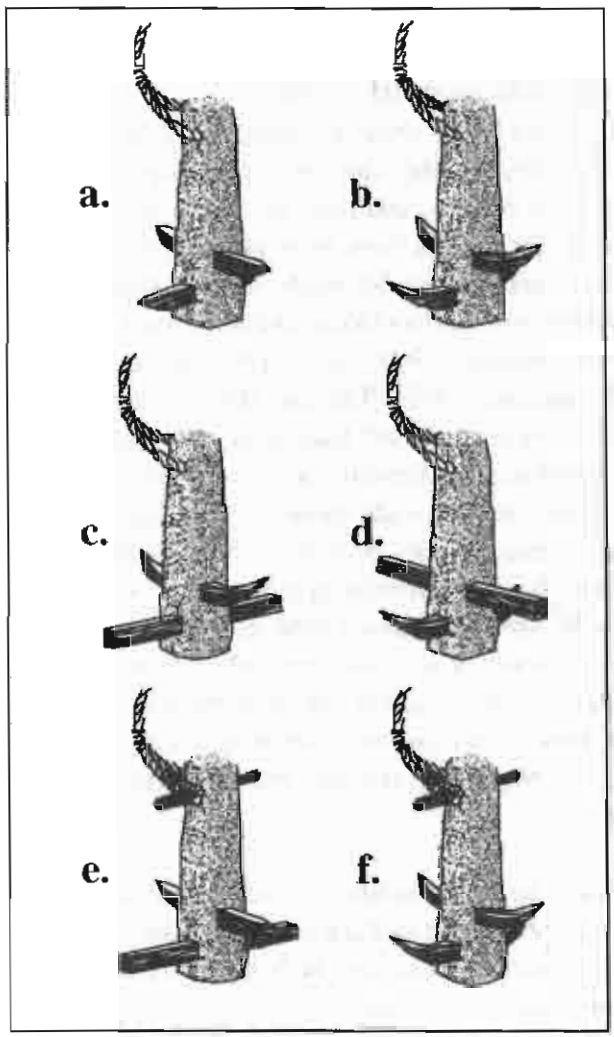


Figure 13. Variations on stone anchors: a.Grapnel with four straight arms; b. Grapnel with curved arms; c.and d. Variations on anchors with two arms and a stock; e. and f. Alternatve anchor cable and stock arrangements.

Only one stone anchor, of 'Mediterranean' type and thus much different from Arabo-Indian types, has been found with any wooden components in place (Grossmann and Kingsley 1996). But t had so little wood remaining that speculation continues about the shape and function of the wooden components.

With the aid of scale models the authors are currently investigating various options for the Arabo-Indian type, testing each for holding power, ease of handling, tendency to foul, proficiency in holding, and suitability to different types of holding ground (i.e. rock, coral, mud, sand). Preliminary results indicate that curved arms increase holding power greatly over straight arms. However, the holes for the wooden components cut through the stone shanks are generally straight-sided, limiting the curvature of any component passing through them. Is it possible that the wooden components were composites, perhaps having wooden or metal flukes added to the wooden arms after they were fitted through the stone shank? As the nominal holding power of an anchor is related more to the size of its flukes than its weight, adding flukes to the wooden arms of a stone anchor would increase its relative holding power. In test results, there was a huge difference in holding power between stone anchors configured as in Figure 13 and a metal Admiralty pattern of the same weight and shank length. Most of this difference is believed to be related to the size of the flukes on the two types.

Other interesting questions raised by the range of sizes exhibited in the corpus are the size of ships which used these anchors and the equipment that was needed to handle them. There are

well-known relationships between the holding power of an anchor (or an array of anchors) and the size of ship they could reasonably expected to hold. The size of the ship might also be expected to have some bearing on the number of crew or the type of equipment that would be needed to handle stone anchors of various weights. It is hoped that further experimentation with replica stone anchor shanks will shed some light on these questions.

The single-hole stone anchor is interesting in that it is a style typical of the Bronze Age. Similar stone anchors were discovered during the excavation of Dwarka (Rao 1987). This is a simple 'weight' anchor which depends not on arms or flukes to hold, but only on its weight. It is suitable for small craft anchoring in areas where the bottom is rocky. Though this type of anchor has a very long history it is not known how long the type continued in use. On the East African coast the single-hole anchor was in use at least into the 1970's (Chittick 1980).

The quern was apparently being re-used as a mooring. It is thought that the quern, or hand grindstone, had largely disappeared from use in most of the Middle East by the tenth century (Forbes 1964).

If it can be determined, the provenance of the stone from which each of the artefacts was made could indicate trade patterns, or intra-cultural contact.

Conservation of the artefacts

After their delivery to the storage facility at Said bin Sultan Naval Base, the recovered artefacts—two stone anchors, a ringstone and a quern—were all given a preliminary surface cleaning. Unfortunately time did not permit the complete initial cleaning of the stone anchor shank GHA2. GHA1 needed little cleaning , as most had been done at Ra's al Jinz. The ringstone and quern, having been cleaned of their mantle of marine encrustation were treated with dilute hydrochloric acid (10% v/v) to remove the remainder of calcine deposits. As both these artefacts are basaltic, there was no danger of damage to the artefacts themselves from the acid.

Following cleaning all four artefacts were placed in tanks filled with fresh water. There is some possibility that prolonged immersion in seawater would have allowed salts and chlorides to leach into the stone and if these were not removed by soaking in fresh water, surface exfoliation of the stone upon drying may occur.

The tank for the quern and the ringstone were supplied by RNO, and a purpose-made GRP tank with integral drain was generously donated by Amiantit Oman SOAC. The artefacts will remain in fresh water soak for some months, with the water changed every few weeks and the levels of chlorides and salts monitored. Once no trace of chlorides and salts can be detected, the quern and ringstone will be removed from the freshwater and allowed to dry. The two stone anchors will require additional cleaning of surface encrustation.

Team 2

The expedition was scheduled to resume on 16 March in Musandam, with the addition of one more staff member and a total of six Earthwatch volunteers, all but one new. However, logistics and weather problems were immediately encountered, making it impossible to do anything until 19 March. On that day the team was flown to Khasab courtesy RNO and RAFO, and taken on board an LCM (landing craft/cargo vessel) for the passage to Goat Island. A camp was established on the northern beach at Goat Island. From this base, and on board LCM 8 *Saba al Bahr* under the command of MUL/1 Abdullah Khalifa Al Riyami, diving operations began.

Figure 14. Map of northern Musandam peninsula.

Choice of dive sites was governed by several factors:

1. Proximity to known land archaeological sites (Figure 14).
2. Presence of headlands, points and promontories where wrecks were likely to occur.
3. Presence of reefs close to the surface and other maritime dangers which could wreck vessels.
4. Location of sheltered anchorages where artefacts may have been dropped overboard.
5. The weather.

Over the next eight days areas of the coast in Khawr Fordha, Khawr Qaltah, Khawr A'Ran, Khawr Kumzar, Khawr Ma'ili, Khawr Ghubb Ali, Khawr A'Shamm, the west coast of Jazirat Umm Ghanam (Goat Island) including Ghubbat Karban, and the waters adjacent Sakhr al Makhruq and Keshal rocks were all searched (Figure 14). Three sites of possible interest were identified in Khawr Kumzar and Khawr Ma'ili, but subsequent investigation revealed that they were natural features or recent artefacts (iron anchors). A large amount of modern wreckage, primarily fibreglass boats from Omani fisherman or Iranian traders, was found in some places but nothing ancient was located.

The difficulties faced in Musandam in finding shipwreck sites or ancient artefactual material stem from three main problems:

1. The rate of sedimentation, coral growth and the exfoliation of cliff faces, all of which tend to bury artefacts.
2. The strength of currents, which sweeps away and scatters shipwreck material.
3. The steep contours and depths of the underwater topography. Wreck remains are prone to being carried into the deep trenches.

While having the potential to preserve wrecksites

and artefacts, sedimentation also hides them. Our impression was that in many areas the rate of sedimentation was relatively high, and the sediment has probably buried important material.

The strength of currents, often a factor in wrecking of vessels, also means that material from wreck sites is likely to be widely scattered and damaged.

Steep contours and extreme depths (for SCUBA diving) mean that artefacts will roll down into the deep trenches, making discovery unlikely except by ROV.

Having said that, there is a great deal of terrestrial archaeological material in Musandam. As most villages and archaeological sites in Musandam are accessible only by sea, this suggests intense sea-borne activity. Historical records and the archaeological evidence on land attest to the importance of the region for maritime activity over millennia. We do have some evidence of ancient maritime activity: an enormous stone anchor shank was discovered (and recovered by BSAC 406 and RNO) near Dibba. From the location of this stone anchor (near a steep shore, without apparent settlement site or trade routes nearby), we have the impression that the vessel carrying it was in danger and may have been wrecked. However, inspection of the sea bed near the anchor site by BSAC 406 divers has so far failed to find any trace of shipwreck. Further survey is planned. It is clear that Musandam retains its potential for significant maritime archaeological discoveries.

Summary of Musandam Sector Diving

20/03/97 Thursday

Khawr A'Ran

It had been our intention to search the bay (Ghubnat Karban) on the western shore of Umm al Ghanam but a strong south-westerly breeze made conditions there impossible. Instead, the expedition took the LCM into Khawr A'Ran and dived the eastern shore of Ra's Mukhalif (west side of the khawr), the end of khawr and eastern shore to a position of 26°21.6N. These areas were searched by depth contours, with each pair of divers assigned to particular depths (9-12 metres, 12-15, 15-18, and 18-21 metres). Nothing of interest was found and the diving operations were moved to Khawr Kumzar.

Khawr Kumzar

The LCM anchored about 1 km from Kumzar village and divers were sent to search from the western edge of Kumzar across Qoqba beach to adjacent northern headland. A large cylindrical object, about 2 metres in diameter and protruding from the sand was discovered in about 15 metres depth at GPS position 26°22.31N, 56°21.49E; 40 435976E, 2917021N. This position was just off the northern headland of Qoqba beach, near a flat rock just off the headland. The object was marked with an SMB for further investigation. Nothing else of interest was found.

21/03/97 Friday

Khawr Ghubb Ali

An underwater area of 60000 square metres just off the beach and south of the village of Ghubb Ali was searched by swimline in six 50-metre wide swaths, 200 metres long. Visibility was not good and divers were spaced at about 4-metre intervals. The swimline search started from the beach and reached a maximum depth of 6 metres 200 metres offshore. Nothing but modern debris (and little of that) was found. The bottom topography was featureless sand. The consensus of those who took part was that old artefacts were likely to be well buried in the sediment. The area is deep inside the khawr and well protected from storms, so artefacts are very rarely likely to be uncovered by wave activity.

Snorkellers examined a small bay to the south, just west of Ghabina and east of Ghubbat Qadimah, where the bottom was sand and reef. Nothing of interest was located.

22/03/97 Saturday
Khawr Kumzar
The large object in Khawr Kumzar was relocated and confirmed to be a lump of rock.

Reconnaissance was made along the western headland from Ra's Mukhalif, survey at depth contours to a maximum of 30 metres.

23/3 Sunday
The small bay between Khawr Kumzar and Khawr Ma'ili was systematically searched (Figure 14).
Khawr Ma'ili
The western shore was covered by four snorkellers. Some modern debris and a few six-foot sharks were noted. Shore of eastern headland was dived to 30 metres. It was noted that the chart is not correct, the 30 metre contour extends much further out than charted. Three pairs of divers did 30, 20 and 15 metre contours. Other pairs were put in to do 20, 15 and 10s across the headland on the eastern side of the khawr.

24/3/97 Monday
Mushkan
In the position approximately 22°23.5 N, 56°24.8E is a set of rocks presenting a hazard to navigation. It was thought worth a look and a pair of divers with floats attached was sent in. The seaward side of the rocks drops off very sharply. Visibility was about 20 metres, and maximum depth of divers was 21 metres. Strong currents were encountered. Making numerous passages around the pinnacle, the divers found some wreckage, but it was all modern.

Ghubnat Karban
With an easing of the southwesterly wind we moved ship to 'Onion Beach' , Ghubnat Karban on the north-western end of Jazirat Umm al Ghanam (Goat Island). A 600 metre jackstay was laid between the headlands on an approximately North-South line and divers on a 20 metre long swimline searched along both sides of it. Other divers scoured the coast of the northern headland to a depth of about 12 metres. The southern headlands were searched about 20-40 metres offshore by depth contours to 12 metre depth. We then conducted a tow search with two snorkellers close in along the perimeter of the bay and the headlands either side of Ghubnat Karban. The northern search extended to Sifat Shaykh, the southern to approximately 26°21.7N (Figure 14).

25/3/97 Tuesday
Khawr Al Quway
We searched the western shore of Ra's Shuraytah, but the counter current caused some problems.
A second dive, from the western promontory of the headland to 26°22.9N covered more ground. Nothing of interest was noted.

We then shifted the LCM around Goat Island and anchored on the SW side (26°20.5N, 056°20.45E). From there a towed snorkel search of the western coast from 26°19.8N, 056°20.9E to the southern cape of Ghubnat Karban (26°22.9N, 056°20.5E) was conducted. This was a very effective technique for depths to about 10 metres. Only modern debris, such as outboard motors located. The procedure attracted curious sharks.

26/3/97 Wednesday
Khawr Al Quway
The southern approaches to Khawr Al Quway on the eastern side, in vicinity of Khawr Gharam were searched at depths from 9 to 18 metres. There is an archaeological site on land here and we had hopes that some corollary evidence might be found in the water. But from an archaeological point of view this was the most disappointing dive of all, as the seabed was completely barren.

Khawr A' Sham
The LCM was moved to Khawr A'Shamm and anchored west of Telegraph Island, at 26°19.88N, 056°21.58E (Figure 14). From one of the rubber

boats an attempt was made to locate by hand bearings and manual depth sounding the shallow pinnacle (depth 2.1 metres) west-north-west of Telegraph Island which is shown on the Admiralty chart. This effort was without success. Least depth encountered was 9 metres.

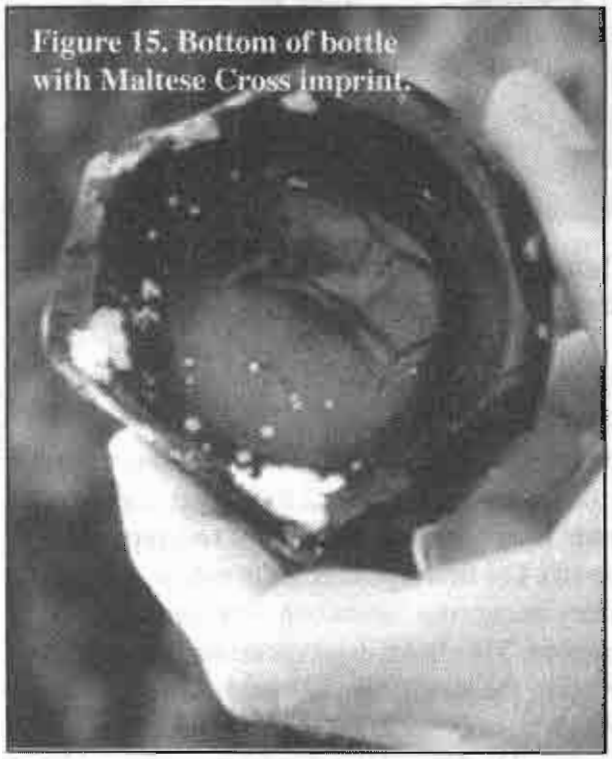


Figure 15. Bottom of bottle with Maltese Cross imprint.

Divers reported visibility reasonable above six metres depth, decreasing to poor beyond that. Snorkellers around Telegraph Island had a little success, finding numerous bottles and pottery sherds. Two broken bottles (bases) and two pottery sherds were recovered. The pottery looks relatively modern, the bottles perhaps older. Both bottles were heavy and hand blown in moulds, one had a Maltese cross on the bottom (Figure 15).

27/3 Thursday

The final day of diving. Departure was delayed until about 0830. The wind was moderate south-westerly. The LCM anchored at position 26°22.863N, 056°22.745E.

Two divers dived the water around Makhbuk to a depth of 30 metres. Visibility was good (perhaps 20 metres) and the current strong in some parts.

Six pairs of divers were put in along the eastern face of Ra's Shuraytah in Khawr Fordha searching on depth contours to maximum 18 metres.

It was decided to search the eastern headland of Khawr Fordha (Ra's Rarak), and five pairs of divers were deployed. Depth contours were searched at 9, 12, 15, 18 and 21 metres.
Modern debris was all that was reported.

Although discoveries in Musandam did not fulfil our hopes, the expedition did manage to search many square kilometres of sea bed. At the very least we have eliminated areas from further visual searches. It must be remembered however that the ancient artefacts may remain undiscovered in these areas, hidden by sediment or coral growth.

Recovered artefacts

Below is a summary of objects recovered by the project to date. All of these objects are now undergoing conservation treatment at facilities at Said bin Sultan Naval Base, Wudam. I am indebted to Dr Ingeborg Guba of the Department of Petroleum / Mining Engineering of the College of Engineering at Sultan Qaboos University for the geological information which follows.

RAJ 1 Stone anchor

The anchor was discovered in 1994 on a beach approximately 3 miles north of Ra's Al Jinz. It is approximately 1.77 metres long and estimated to weigh 255 kg (Figures 16 and 17). One face of the stone is slightly curved (convex) in the longitudinal plane, probably reflecting the natural curve of the parent rock. There is no marine accretion on this anchor. The anchor is made from high-grade metamorphic rock displaying gneissosity of minerals such as quartz and feldspar, muscovite and amphibole. This rock has a hardness of 7.0, a density of about 2.7 and is difficult to work. The rock belongs to the crystalline basement of the Arabian shield. Although this type of rock is found in Jebel Ja'lan near Kamil, large unweathered blocks such as this one are rare. Similar deposits are found near Mirbat. Other possible sources are Saudi Arabia near the Red Sea and India.

Figure 17. Fisherman with stone anchor shank RAJ 1 near Ra's al Jinz.

SHI 1 Stone anchor

Recovered from the beach at Shiya, this anchor is large (approximately 2.85 metres long) and made from sedimentary stone of two types (Figure 18). The first type is beige in colour and comprises micaceous sandstone with carbonate cementing. This layer displays cross-bedding, indicating the sandstone was probably deposited by a river, or possibly between a river and a shallow sea. The lower layer is grey in colour and is a carbonatic silt stone. This rock is very common and found all along the coasts of Oman, Iran and India.

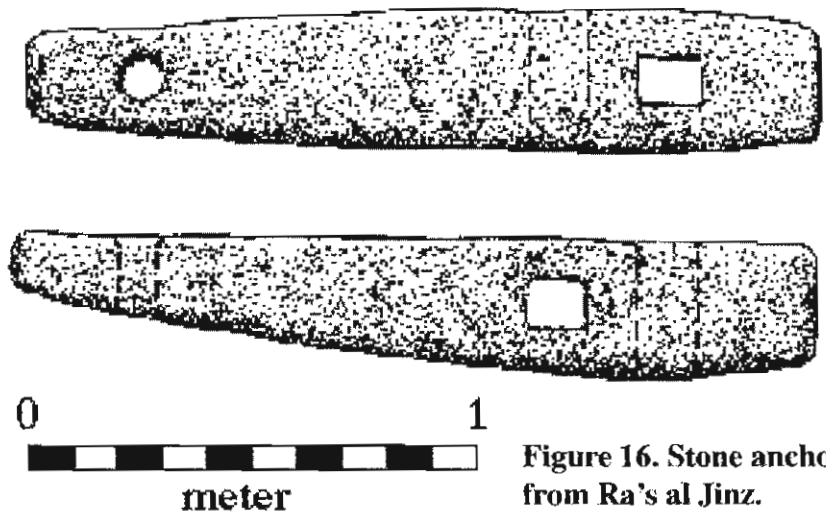


Figure 16. Stone anchor from Ra's al Jinz.

The stone anchor lacks the usual round hole at its smaller end, but morphometric comparisons with other large stones indicated this shank is somewhat short proportionally and may have been broken. The pattern of chisel marks in the rectangular holes indicate that they were made by metal tools, cutting from both sides of the shank in three stages with frequent turning of

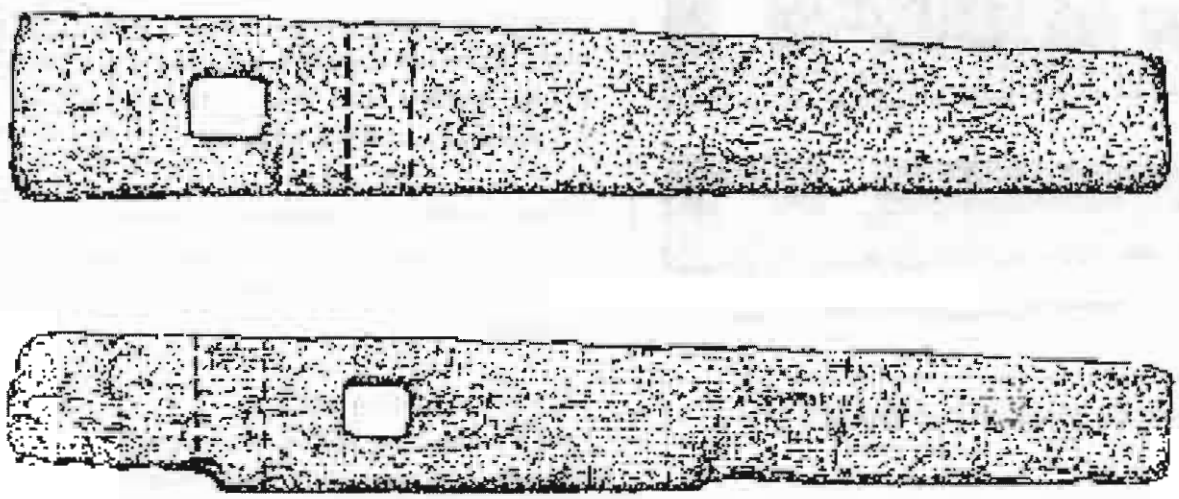
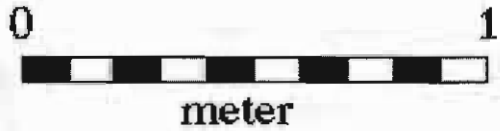


Figure 18. Limestone anchor shank SHI 1 from Shiya.



the stone during the process. Perhaps not surprisingly, the chiselling and chasing was done by a right-handed stonemason. There is no marine accretion evident on this anchor stone .

SHI 2 Ringstone (Figure 19b)
This object was recovered from the intertidal zone at Shiya, approximately 1.5 km north of SHI 1. The artefact is ironstone comprising haematite and limonite. The original stone would have been very porous, a sandstone or more probably limestone, and the pores have been filled with iron oxides in solution. It has a density of about 4.0. There is some marine accretion evident on this ringstone, most of it in the axial hole, or in recesses on the exterior. The pattern of accretion indicates that the ringstone was exposed to long-term weathering by wave action and erosion by sand, cleaning most of the outside surface of accretion. Given the relatively light weight of the stone, it is very possible that it could have been moved about by storm wave action.

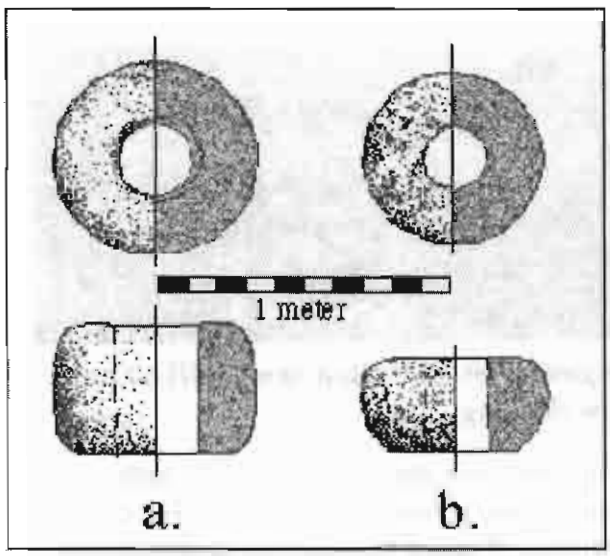


Figure 19. Ringstones from a. A'Sulayb (now at A'Seelah) and b. Shiya.

The most likely source for this stone is the area south of Quriyat.

The other ringstone illustrated here (SUL 2, Figure 19a) has not been recovered by the project, but was recorded at the village of A'Seelah. It had originally been discovered just offshore by villagers from A'Sulayb on the Ja'lan Indian Ocean coast some years ago. The stone has since been spirited away by people from A'Seelah, and it now stands in a village square at A'Seelah (Fig-

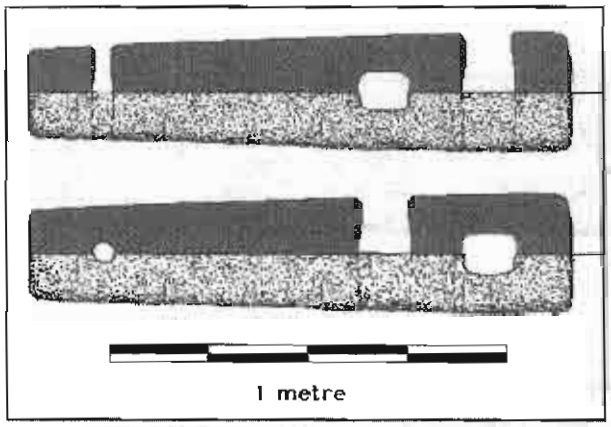


Figure 20. Stone anchor shank GHA 1.

ure 19a). It is made from grey granite, with a carefully worked smooth surface. The axial hole is slightly tapered.

GHA 1 Stone anchor
Found about 0.5 km from the shore near Ghalilah in 15 metres of water, orientated in a North-South direction with the narrow end pointing south. It was moderately encrusted with accretion and marine growth. On cleaning the anchor after recovery it was noticed that marine borers had attacked the stone, leaving numerous small holes.

Approximately 1.37 metres long and measuring about 0.30 metres square at the larger end, it is a dense (about 3.2) basalt with manganese mineralisation and estimated to weigh 240 kg (Figures 20 and 21). This is a large piece of columnar basalt, which occur naturally in this shape (though normally six-sided rather than four). It could therefore require a minimum of working to the finished state. With a hardness of about 6.5 working would be difficult.

Omani basalt is fractured and does not normally occur in such large blocks. Possible sources for this one are Yemen, India, or Baluchistan (Makran).

GHA 2 Stone anchor
Found just over 10 metres from GHA 1 in a gully between two reefs, this stone anchor was oriented at 112° It is of similar size (1.52 metres

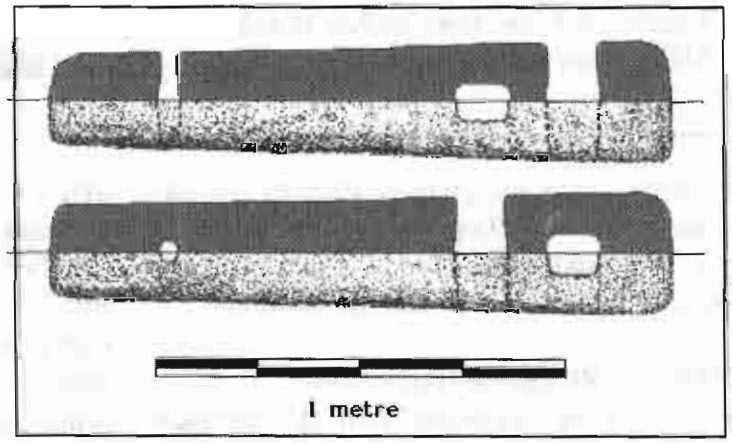


Figure 22. Anchor shank GHA 2.

Figure 23. Stone anchor shank GHA2 before cleaning.

long) and sectional dimensions and made from exactly the same rock as GHA 1 (Figures 22 and 23). It is estimated to weigh about 305 kg. Both GHA 1 and GHA 2 are almost certainly from the same vessel, which may have been trying to hold itself off shore against a shamal.

QAL 1 Ringstone

Hemispherical in shape with a hole of approximately 165 mm diameter through the centre, this artefact is 0.54 metres in diameter and approximately 0.3 metres high (Figures 24 and 25). It is made from dense olivinic basalt which is rich in iron. The source of the stone is probably Yemen, or perhaps India, where massive blocks of this rock are available.

Figure 24. Ringstone QAL1 after cleaning.

With a density factor of about 2.9 the ringstone is estimated to weigh 130kg.

All ringstones in Oman have been discovered in a maritime context, in loose association with stone anchors. It is reported that this type of ringstone was used in the Maldives into the 1970's as a 'mushroom' type anchor for anchoring on coral reefs, usually during bait fishing (Maniku, personal communication, 1997). The ringstone was used for two reasons: in order to prevent snagging on the coral (as might happen with a grapnel type) and to minimise damage to the coral. In the Maldives a forked branch was placed through the hole of the ringstone, the fork preventing the branch (functioning as the shank) from slipping through the hole (Figure 26). Maniku also said that the fishermen kept a phial of shark oil, and a few drops of the oil was used to calm the water so that they could better see the nature of the bottom before casting anchor. This precaution helped to minimise damage to the reefs and prevent the anchor getting snagged.

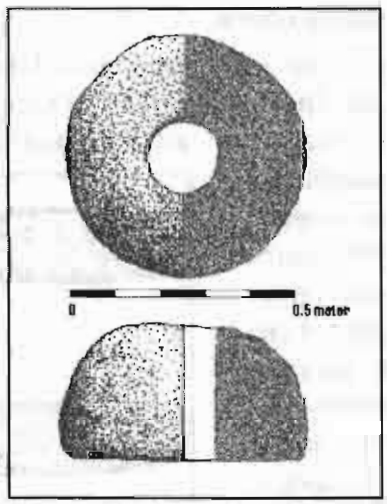


Figure 25. Drawing of ringstone QAL 1

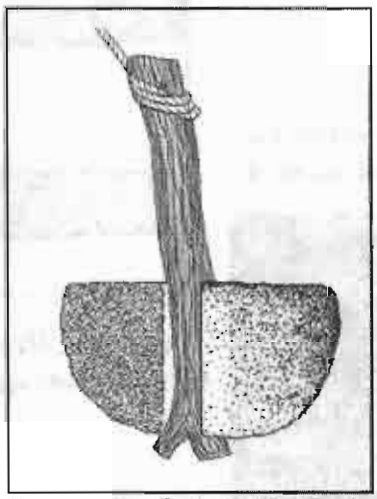


Figure 26. One method of using a ringstone as a 'mushroom' anchor.

It was noted during the 1995-1996 expedition that the ringstones found at A'Seelah (originally found at A'Sulayb) and Shiya had tapering axial holes (Figure 19 a&b). This taper may have been used to hold the tapered wooden shank of a 'mushroom' anchor, in a slightly more sophisticated version of the Maldivian model.

Raban, quoting from an unpublished manuscript by Hornell, reported that this type of ringstone has also served as a mast step on Arab boats (A. Raban, pers. comm., 1997).

Similar objects have been recovered from excavations of 3rd millennium sites in the Indus Valley, but there is no agreement on what their purpose might be (During-Caspers 1989, Mackay 1958-59, Marshall 1973).

Despite the similarity of form, it is the authors' opinion that the Indus Valley artefacts are probably not the same as those in Oman.

We would also like to report that another Arabo-Indian stone anchor shank was discovered during the 1994 expedition in the inter-tidal zone near the site where ringstone SUL 2 was originally discovered at A'Sulayb. This stone anchor is approximately 2.4 metres long and estimated to weigh 600 kg.

QAL 2 Grindstone or rotary quern

This is a circular (0.66 m diameter) stone, slightly concavo-convex and approximately 10 centime-

Figure 27. Top of rotary quern.

Figure 28. Underside of rotary quern.

tres thick. This would have been the upper half of a pair of grindstones, the lower of which is missing. Found in about 4 metres of water on a sandy and rocky bottom with shell underlayer, this object may have been reused as a small boat mooring. On the convex side it has pairs of connecting holes near the edges on opposing sides. A tapered off-centre hole of 3-4 cm diameter pierces it through, and on the concave side is a central circular notch about 4 cm deep and 3 cm in diameter, presumably to receive the spindle of the lower half. A shallow radial groove can be seen stretching from the centre to the edge. (Figures 27 and 28). It is made from vesicular basalt, the source of the material probably Yemen.

DIB 1 Stone anchor

At nearly three metres long, this is easily the largest stone anchor shank in the possession of

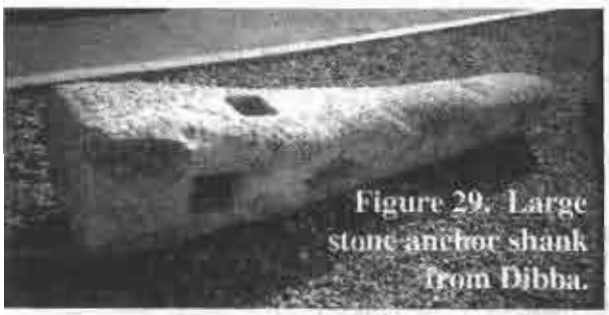


Figure 29. Large stone anchor shank from Dibba.

the project (Figures 29 and 30). It was discovered and recovered by Sharjah BSAC 406 divers, with the assistance of RNO for transport and storage. The anchor was lying at a depth of about 10 metres close to a steep-to shore, about 15 kilometres north of Dibba. This is not an anchorage and we must assume this anchor comes from a vessel that was in trouble. The anchor shank is made of diorite and is estimated to weigh nearly 1.3 tons. There are numerous chiselled indentations along its edges, particularly near the larger end. These most probably are evidence of the quarrying process. Alternatively, they may have something to do with the function or composite configuration of the anchor itself, but this is thought unlikely. Diorite occurs in Oman, and allegedly was exported to Mesopotamia in antiquity.

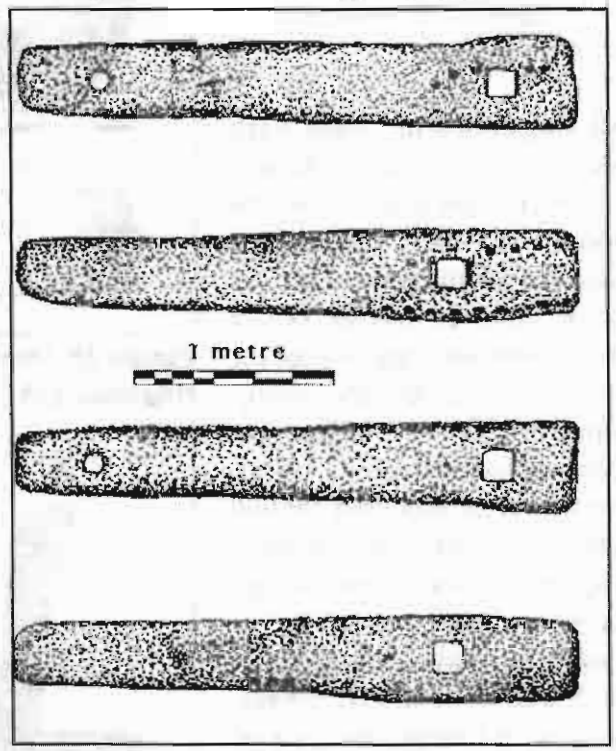


Figure 30. Drawing of stone anchor shank DIB 1. Note quarrying marks on edges.

Recommendations

The archaeological discoveries underwater off Qalhat are very significant to the maritime history of the Sultanate. As such, they should be protected just as any significant archaeological site. Archaeological artefacts, whether found on land or in the sea, are attractive to the public, who are often tempted to take objects as souvenirs. This attitude prevails particularly among some elements of the sport diving community, who seem to believe that any object in the sea is subject to salvage, or more bluntly, looting.

It is feared that when the discoveries near Qalhat become known they will be threatened by looting. Apart from the destruction of the site, the loss of in situ information to be gained from having the artefacts remain in their original locations will be serious.

This can be prevented, or at least limited, by a number of measures.

1. Education:

A. Schools

B. Sport Diving Clubs

C. Community Groups

Programs to educate the public to the precious nature of underwater artefacts, emphasising the ethics of respect for their integrity and their value in situ.. Illustrated talks to students and dive groups, and distribution of literature would help control looting or site destruction.

2. Restriction:

A. The protection of archaeological material on land should be fully extended to cover underwater artefacts as well.

B. In the case of the Qalhat underwater site, signs should be posted on the beach near the site indicating that it is an archaeological site and that removing any artefact from the area is an offence. As much of the underwater archaeological material at this site is in relatively shallow water (less than five metres depth) many of the smaller artefacts could be taken.

C. A person from modern Qalhat should be designated to act as liaison to the government authorities to report any activity thought to be detrimental to the site.

D. The site could be declared a diving exclusion zone, subject to a diving permit to be issued by the appropriate authority.

E. Police in Sur should be alerted to the value of the underwater site and requested to check any suspicious activity at or near the site.

3. Involvement: In conjunction with the education phase, the sports diving community could be enlisted in the further search and survey of any site. Including them in the process would help them to appreciate the importance of protecting the site and encourage them to do so.

4. Tourism: Underwater archaeological sites can become attractive dive sites for tourists. With the expansion of tourism in the Sultanate, the underwater site near Qalhat and others that will be discovered could be utilised as enjoyable and educational dive sites.

This is already done in many parts of the world, with 'wreck trails' marked out for SCUBA divers to enjoy. These 'wreck trails' or 'artefact trails' can also be valuable educational tools.

The survey of the area is not complete and should be extended to cover the entire bay. The survey should include magnetometer and sub-bottom profile searches as well as visual surveys. A magnetometer or underwater metal detector survey might locate significant iron or copper remains (such as cannon, anchors or ingot cargoes) while the sub-bottom survey could locate large artefacts or wrecksites buried under sediment. All finds must be carefully surveyed, identified and their locations accurately plotted. The wadi at Qalhat deposits a large amount of silt which is likely to have covered and preserved ancient artefacts. It is believed that there are a great number of discoveries to be made in the region, and these, in addition to the ones already discovered must be properly catalogued and surveyed.

APPENDIX A

Personnel

Staff from the WA Maritime Museum, two Earthwatch volunteer teams of three and six people respectively, six self-funded volunteers from the British Sub-aqua Clubs of Oman and Sharjah (United Arab Emirates) and personnel of the Diving Unit from the Royal Navy of Oman plus various crewed support facilities including an LCM for the period 16-29 March.

Team 1, 28 February—13 March
Staff
Pat Baker, Diver, photographer, videographer
Jon Carpenter, Diver, conservator, videographer, photographer
Helen Kirkbride, Accountant and Administrator
Chester Pavlovski, Surveyor, Finds Assistant
Tom Vosmer, Expedition Leader

Earthwatch
David Jewell, Historian, Surveyor
Jeanne Lewis, Surveyor
Harley Young, Diver

BSAC (Oman)
Ken and Dot Gorman (2 days)
Mark and Anne Insole (2 days)

RNO
RD Bob Nankivell, Diving Group Commander
MUL/1 Juma Mossa Al Ghailani, Diver
WKL Richard Honeychurch, technical officer
RQB Essa Habshi Juma Al Kindy, Diver
ARF Mansoor Ali Abdul Razaq Al Balushi, Diver
Rashid Humaid Salem Al Azoobi, Diver
Rashid Mubarak Al Adawi, Diver
Fadhil Abdullah Al Azabi, Diver
Salim Khalfan Al Balushi, Diver

Cooks: P.K.M. Abdul Rahman
Fadhil Salim Al Batashi
Driver: Abdul Majid Al Balushi (heavy lift vehicle)

Equipment
Basic personal diving gear, compressor, generator, 4WD vehicles (two from RNO, two courtesy of Desert Line Projects LLC), 10-ton truck with crane, three rubber boats and engines, jackstays, risers and weights, surface marker buoys (SMBs), GPS, hand bearing compass, Electronic Distance Measuring device (Distomat 15 EDM) and Wild 1600 theodolite (both courtesy of Petroleum Development Oman), measuring tapes, charts and UTM maps, camping equipment.

Team 2, 16-30 March
Staff
Pat Baker, Diver, photographer, videographer
Jon Carpenter, Diver, conservator, videographer, photographer
Helen Kirkbride, Accountant and administrator, camp organisation
Chester Pavlovski, Surveyor, finds assistant
Corioli Souter, Maritime archaeologist, diver
Tom Vosmer, Expedition leader

Earthwatch
Clive Ashbolt, Surveyor
Claire Barnes, Diver
Brian Evans, Diver
Eddie Kennedy, Diver
Harley Young, Diver
Kathy White, Diver, Earthwatch staff representative

BSAC (Sharjah 406)
Laith and Juliette Haboubi (4 days)

RNO
Diving Support
MUL/1 Abdullah Khalifa Al Riyami, CO LCM 8 Saba al Bahr
MUL/1 Najeeb Ahmed Al Maini, Commander Diving Group, Diver
WKL/2 David Humphreys, Dive Master
RQB/1 Essa Habshi Juma Al Kindy, Diver
RQB/1 Khalifa Said Abdullah Al Harasi, Diver

ARF Mansoor Ali Abdul Razaq Al Baluchi, Diver
ARF Said Abdullah Al Mamari, Diver
NBA G.S. Kurup, Engineer
NBA Yousef Mubarak Al Amri, Diver
NBA Yaqoob Mohamed Al Saifi, Diver
NBA Ahmed Al Shandudi, Diver
NBA Abdullah Mohamed, Diver

Cooks: P.K.M. Abdul Rahman
ARF Fadhil Salim Al Batashi

Base Support
AQD Essa Kallender, CO RMB
MUL/1 Emad Mubarak Al Alawi, AXO RMB
MUL/1 Ali Mohamed Al Balushi, CO LCM (Khasab—RMB)

Abbreviations

RNO =	Royal Navy of Oman
RAFO=	Royal Air Force of Oman
CO =	Commanding Officer
XO =	Executive Officer
AXO =	Assistant (or Acting) Executive Officer
RMB =	Ra's Musandam Base
SBSNB=	Said bin Sultan Naval Base
LCM =	Landing Craft Mechanism (Charlie Boat)
EDM =	Electronic Distance Measuring device
GPS =	Global Positioning System
ROV =	Remote Operated Vehicle
SMB =	Surface Marker Buoy
UTM =	Universal Transverse Mercator

APPENDIX B

Conservation of Maritime Archaeological Artefacts in Oman

An on-site conservator experienced in the preservation and treatment of a wide variety of materials recovered from maritime archaeological sites was in attendance throughout the expedition. Pre-expedition planning was based on known artefact recovery (stone anchors) with further consideration toward artefact materials likely to be found following the discovery of any shipwrecks. Conservation equipment and materials were obtained in Oman as required. No problems were encountered in this regard.

Iron Artefacts

During initial underwater searches for shipwreck sites a number of wrought iron anchors were located. None of the anchors were recovered. As is frequently the case with iron anchors substantial material has survived. Inspection of these artefacts implied that future recovery would be worthwhile. In-situ conservation measures should be considered for these objects as the installation of sacrificial anodes would stabilise these objects and begin the removal of corrosive salts prior to recovery.

Stone Artefact Conservation

During the recent maritime archaeological investigations of waters along the coast of Oman a number of stone artefacts were discovered. Two stone anchors, a mill stone and a 'ring stone' were recovered. All of these objects were given the same initial conservation treatment. To prevent potential damage from drying each was wrapped in hessian (burlap) which was soaked in seawater and sealed in polythene sheeting. To avoid damage during travel over the countries rough terrain, a bed of sandbags was prepared. The artefacts were held for several days in the moist environment which was maintained by the wrapping. The surfaces of the stone were generally encrusted with calcium carbonate deposits derived from marine life colonisation. Under-surfaces, where partial burial in the seabed had occurred, were relatively free of marine growth.

Removing the Encrustation

Careful probing of the surface of the artefacts provided an initial test of the hardness of the stone. This assessment proved that all would tolerate controlled chipping to remove the bulk of the encrustation. Small hammers and chisels were used to carry out this work (Figure 31). A geological assessment and identification of the types of stone permitted further cleaning of the 'ring stone and anchors using a localised application of dilute hydrochloric acid (10 % solution). Acid residues were promptly rinsed away with seawater. Following this initial treatment all stone artefacts were placed in long term seawater storage solutions. The establishment of a permanent conservation program and facility will eventually permit the stone artefacts to be desalinated in fresh water.

Figure 31. Removing accretion from stone anchor shank GHA1 by mechanical means.

Stone artefacts recovered during previous expe-

ditions were examined for potential deterioration, no evidence of damage was apparent.
Ceramic and glass artefacts

Two samples of broken ceramic material and two glass bottle bases were collected from the sea surrounding Telegraph Island in Khawr A'Sham. All samples were initially kept immersed in seawater to prevent damage from the formation of salt crystals . These artefacts were generally free of encrustation which was simply removed by hand.

These items, which have not yet been dated, are presently stored in freshwater until controlled desalination can take place.

BIBLIOGRAPHY

Chittick, N., 1980. Stone anchor-shanks in the Western Indian Ocean, *International Journal of Nautical Archaeology*, 9.1, 73-76.

During Caspers, E. C. L., 1989. The 'calendar stones' of Moenjo-daro reconsidered, *South Asian Archaeology, Monographs in world archaeology* 14, 83-95.

Forbes, R.J., 1964. *Studies in Ancient Technology*, Vols 1-10, Brill, Leiden.

Grossmann, E., and Kingsley, S.A., 1996. A three-hole stone anchor with wood remains from Crusader Arsuf (Apollonia), Israel, *International Journal of Nautical Archaeology* 25.1.

Kapitän, G., 1994. Stone shank anchor of the Arab-Indian trade period - were they mooring anchors?, *Bulletin of the Australian Institute for Maritime Archaeology*, vol. 18 No. 2.

Mackay, E.J.H., 1957-58. *Further excavations at Mohenjo-daro*, Vol II, New Delhi.

Marshall, J., ed., 1973. *Mohenjo-daro and the Indus Civilization.*

Owen, J., 1995. Do anchors mean ships? *Profumi D'Arabia.*

Raban, A., 1990. Medieval anchors from the Red Sea, *International Journal of Nautical Archaeology* 19.4.

Rao, S.R., 1987. Marine archaeological explorations off Dwarka, northwest coast of India, *Indian Journal of Marine Sciences*,16:22-30.

Tripati, S., and Gaur, A.S., 1997. Stone anchors from the Sindhudurg Fort on the west coast of India, International Journal of Nautical Archaeology 26.1: 51-57.

Vosmer, T., 1996. Field Work in Oman, 1995-96, *Western Australian Maritime Museum Report No. 116.*

Whitehouse, D., 1970. Excavations at Siraf, 3rd interim report, *IRAN: Journal of the British Institute of Persian Studies* v.8, 1-18.