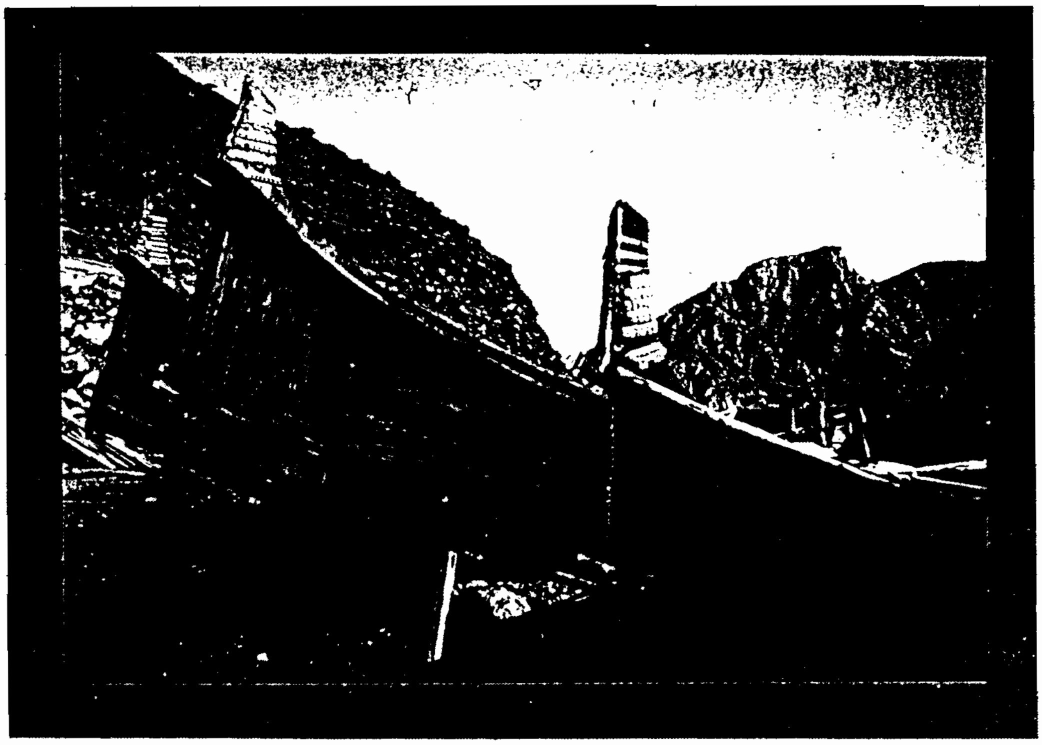
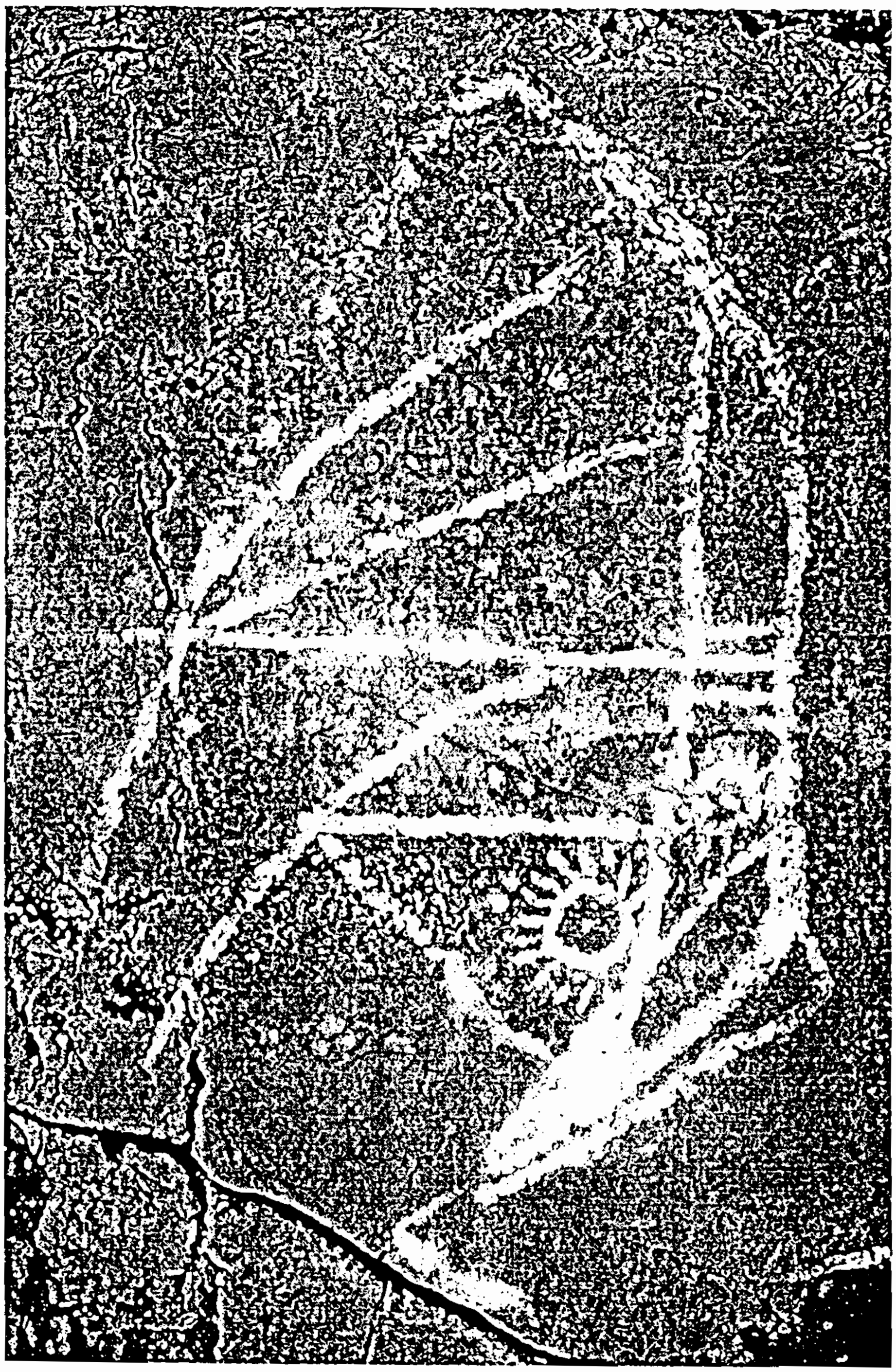


A Survey of Traditional Vessels of the Sultanate of Oman

The Omani Dhow Recording Project Field Research, 1992

Report - Department of Maritime Archaeology
Western Australian Maritime Museum, No. 69



A Survey of Traditional Vessels of the Sultanate of Oman

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Field Research, 1992

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Drawings by: Thomas Vosmer and Alec Tilley

Acknowledgements

The primary funding for the field work came from Earthwatch and the Principal Investigator is indebted to Earthwatch and its Research Corps for making the project possible. The field work was also generously supported with assistance from the Australian Research Council, E-Z Up (Oman), GENETCO (Oman), Khimji Ramdas (Oman), Kodak (Australia), Mark Rent-A-Car (Oman), Matrah Cold Stores (Oman), Oman International Bank S.A.O.G., Petroleum Development Oman, Royal Navy of Oman, the Royal Oman Air Force, Safeways (Oman), Seeb Novotel (Oman), Singapore Airlines and the Western Australian Maritime Museum. The authors are indebted to Mr Bill Leonard, master shipwright, for his valuable advice, suggestions and observations. We are also indebted to Mr Rod Salm, formerly of the Coastal Management Corporation in the Sultanate for the guidance and advice he gave. Special mention must go to the Ministry of National Heritage and Culture for their cooperation and assistance. The authors also wish to express their thanks for and appreciation of the assistance by many private individuals, too numerous to list, both Omani and expatriate, who offered advice, information, encouragement or the loan of equipment. Thanks also goes to the two teams of Earthwatch volunteers, without whose financial contributions and enthusiastic field assistance this project would never have been possible.

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Background

The Sultanate of Oman has a rich maritime heritage, dating back at least 5000 years to the time when Oman was a rich source of copper for developing civilisations in the entire region and Omani sailors were pioneering the development of maritime skills and technology. Archaeology on land has highlighted the importance of seaborne commerce and a littoral society heavily dependant on subsistence from the sea. Today, though the ancient sea trade in copper, spices, leather, animals, frankincense and ambergris has disappeared and the fishing industry has been modernised, the echoes of the great Omani seafaring traditions and the maritime technology that enabled them to flourish are still evident in the design and construction of traditional vessels to be found in the Sultanate.

Several authors have written about, drawn and photographed various aspects of traditional Arab seagoing craft. In the mid 19th century, Amiral Paris described and produced 'measured drawings' of several types of Arab vessels (Paris, 1843). Clifford Hawkins and David Howarth have published general surveys of the dhow, illustrating and describing a range of vessels from the western Indian Ocean (Hawkins, 1977; Howarth, 1977). *Oman, A Seafaring Nation*, a fine book published by the Ministry of Information and Culture of the Sultanate of Oman gave an excellent account of the history of Omani seafaring and the ships employed (Ministry of Information and Culture, 1979). Many other authors have written on the subject in books, professional papers or journal articles (see bibliography). With all the material that has been written, however, there are still particular aspects that have not been documented.

The Omani Dhow Recording Project is directed at recording the type of information that has not yet been fully documented, with detail largely overlooked in the past. The project seeks to record information on several levels: macro characteristics (such as hull shape and general construction configuration), micro features (such as details of construction joinery, materials analysis), and general data about materials processing as well as handling and use of the vessels.

The project will operate on three basic levels:

1. Data collection
2. Data analysis
3. Formulation of hypotheses and theories

Data collection

The morphology of various types of Arab vessels has not previously been rigorously recorded and it is one aim of the project to record the lines of several examples of each type of craft. While providing a permanent record of the shapes, the lines plans generated from this information also will be used to evaluate by computer the performance and handling characteristics of each documented type. It has been stated (McGrail, 1982) that when recording any vessel, the minimum amount of information gathered should enable a competent model builder to construct an accurate scale model. While providing the detail required for accurate model building, the information from this project will move well beyond the realm of the model maker, serving not only as a basis for permanent three-dimensional records of the types, but also providing tools for investigation into the procedures used in the construction of full-scale vessels. Rigorous recording of the design, morphology and naval architecture, of construction techniques and methodologies, materials and uses, will enable comparative studies to be done with other regional vessels. Detailed construction drawings will be used to expand the corpus of information on Arab and Indian Ocean shipbuilding, and to provide a basis for further examination of the development of Omani maritime technology. Analogous with the typing and dating of archaeological ceramics, examination of details can often be clues to the origins of particular types of vessels. With this type of information, cross-cultural influences may be discerned and clues to historical developmental trends, trade patterns and links with the past elucidated. A survey of the number and types of vessels at several locations along the coasts will provide an indication of their general distribution and numbers. The information gathered therefore could be broadly categorised under four headings: (1) the design, shape or morphology of each type, as well as decorative motifs; (2) the details of the construction, (3) the use of the vessel, and (4) the distribution and numbers.

Data analysis
The data will be examined in an attempt to identify underlying relationships among the various types, to document unique or characteristic features and processes, to analyse uses and suitability of adaptation to function and to illuminate the theory behind the naval architecture of the documented vessels. The information will comprise part of an internationally accessible database on shipbuilding traditions and styles for the Indian Ocean and south-east and east Asian regions.

Formulation of hypotheses
It is hoped data analysis will enable theories to be formed concerning the development of Arab, and specifically Omani, maritime technology within the larger framework of shipbuilding, regionally and historically.

Staff and volunteer researchers
The field work in 1992 was led by Mr Thomas A. Vosmer of the Western Australian Maritime Museum, with staff assistance from Lt Commander Alec F. Tilley, Royal Navy and Royal Oman Navy (retired); and Ms Roxani E. Margariti, of the Institute of Nautical Archaeology based at Texas A&M University. In addition to the staff, seven Earthwatch volunteers assisted during the period from 20 November through 3 December, and four from 4 through 18 December.

Team I Volunteers:	Team II Volunteers:
Dempsey, Bobby (USA)	Chrisulis, Marika (USA)
Kapakjian, Lorraine (USA)	Fentz, Vagn (Denmark)
Lincoln, Carol (USA)	Hanley, Ellen (USA)
Macgregor, John (USA)	Walker, John (USA)
Maitland, Frances (Australia)	
Trusdale, Howard (Canada)	
Trusdale, Mary (Canada)	

The Field Work
Field work for the project was conducted in the Sultanate of Oman from 20 November through 18 December, 1992. The field work was divided into two phases, each of two weeks duration. A wide geographical area was covered with work being done along the Batinah coast between Muscat and Shinas; from Sur to Ra's al Hadd and south to Al Ashkharah, as well as at the village of Kumzar in the Musandam peninsula (Figure 1).

Headquarters for the project field work was the Seeb Novotel. It was there that team members stayed at the beginning and end of each of the two-week field work sessions, and where telephone, facsimile and postal messages were normally received and sent. However, most of the time was spent in the field, camping in the areas where recording was done.

Documentation
With the plethora of vessels discovered (particularly in the categories of *houri* and fishing *badan*) a balance needed to be struck between detailed documentation, i.e. lines and construction plans plus photographs and video, and recording of more general information. In conjunction with the recording of specific and general information, an attempt was made to compile a catalogue of the numbers and types of vessels at the several locations visited. While this list is not comprehensive, it does provide an indication of the nature and abundance, or lack of it, of traditional vessels in the areas visited in the Sultanate.

Lines Plans

One of the primary objectives of the field work was to record by measurement from a three-dimensional grid the shapes of representative examples of the several types of Omani vessel. The tables of offsets created from these measurements and their lines plans are to serve as a permanent record of the morphology of Omani, and generally Arabian Gulf, traditional vessels. They also provide a database for the computer-aided evaluation and comparison of the hydrostatics, cargo capacity, stability and handling characteristics of the several types. Additionally, as many contemporary vessels preserve pure Arabian design characteristics, they may serve as a resource for the reconstruction of any Arabian shipwrecks that may be discovered.

Construction Plans

None of these vessels is built from plans, nor have any detailed construction plans ever been made of them. The Earthwatch teams rigorously documented the construction configurations of three fishing *badan*, two *houri*, one cargo *badan* (*'uwaisiyyah*), one *shashah*, two *baggarah*, one *mashua* and one *battil*. Details of joinery, planking patterns and decoration were also recorded. From these notes, measurements, photographs and sketches, construction plans and general arrangement plans are being produced.

Samples

Fifty-five materials samples were taken during the field work. These included thirty-nine wood samples for species identification, six metal fastenings, three resins, two putty/luting compounds, one rope and three caulking material samples. It is hoped that identification of these substances will help illuminate the trade patterns and cultural links which exist, or have existed among the various boat building communities of the region. Additionally, the identification of wood species being currently used in an active building yard such as Sur may demonstrate evolving international trade patterns.

Oral History

Where possible, interviews were conducted with owners or users of vessels to try to determine the origin, history, method of use and handling of the vessels. Problems of communication naturally arose when persons not fluent in both Arabic and English participated in these interviews. While some members of the team had a slight knowledge of the local language, their command of it was not sufficient to discuss the complex issues involved in vessel design and building. Another problem was encountered with the tendency of owners who, seeing our keen interest in their vessel, would naturally assume we were inspecting it with a view to buying. Their answers to questions were therefore sometimes tailored to making a sale, or by the natural tendency to tell people what one assumes they want to hear. In Kumzar, communication was particularly difficult and we wondered if some of the words encountered were not strictly Arabic. While some, particularly those naming parts of boats, were the same as those found elsewhere in the Sultanate, others were entirely new to us. Despite these problems, information gathered in this way was of immense value and at times a revelation. The project could definitely benefit from the presence of a fluent Arabic-English speaker in the future.

Equipment

Some standard recording equipment for taking lines, such as levels, plumb bobs, string, stakes and tape measures were used. However, each vessel presented unique problems for recording methods, and some basic equipment had to be improvised according to conditions. While the need for such improvisation is common when recording ships' lines, the authors believe the experience gained in the conditions in Oman will enable more efficient and convenient grid and measuring systems to be designed and built for the next expedition.

In addition to the personal cameras brought by the volunteers, the expedition also had two Nikon camera bodies and three lenses: 24 mm, 55 mm and 105 mm, a tripod and a photographic scale. A Sony Hi-8 video camera proved to be a huge asset to the documentation process.

Report Format

Several types of vessel were noted, including *badan* (of two sizes and varieties), *shashah*, *houri* (of several types, pure dugouts, extended dugouts, purely planked, and fibreglass), *baggarah*, *mashua* and *battil*. The names for vessel types used in this report are those recorded as being used by the local people. They may not agree in all cases with names recorded by other investigators. There seems to be, in any case, a certain fluidity in definitions of the various types, both geographically and historically. In order to avoid confusion, the authors have defined each type as referred to in this report in Appendix A. It should be noted that the authors have elected to use the singular form of each type name to denote both singular and plural forms. This is in order to avoid the error of attaching an anglicised plural ending [s] to a transliteration of the Arabic singular name.

The transliteration of words from Arabic into English can lead to some confusion, in that many phonetic interpretations may be valid. For example, the team found the name of a town four kilometres west of Qurum, near Muscat, to be spelled four different ways: Atheiba, Athaiba, Azaiba and Udhaybah. In such cases, the authors have chosen one of the spellings and tried to maintain consistency throughout the report.

Although 'dhow' is a general term, not used by Arabs, it is used here to encompass all traditional Arab boats of the region, including the *shashah*, which is a small vessel fashioned from the spines of date palm leaves (*barasti*).

The project adopted a convention for labelling specific vessels, normally dictated by their physical location in a particular area and their placement relative to each other. A three-character code consisting of the first two letters of the place name, plus a sequential number were used to designate each vessel. Usually the numbering sequence proceeded from left to right along the beach, with the observer facing the sea. For example, at Al Ashkharah, the four cargo *badan* were labelled AS1, AS2, AS3 and AS4. At Al Atheiba, however, due to the large number of vessels of two distinct types (*houri* and *badan*) the letter 'H' or 'B' was added as a distinguishing feature to the standard three-character code.

All measurements are given in millimetres, but are usually to the nearest 5 mm or 10 mm, depending on the purposes for and conditions under which measurements were made and the condition and size of the vessel. The degree of accuracy is noted in the report on each documented vessel.

There was a definite pattern to the distribution of these vessels. Broadly speaking, *houri* and *shu'i* were found in all areas visited. Fishing *badan* up to approximately 11 metres' length were seen along the Batinah coast, whereas at Al Ashkharah were found large cargo *badan* (also called *'uwaisiyyah*) exceeding 15 metres in overall length. What was apparently a cargo *badan* in poor condition with the beak and stern fin removed was located at Mahkleef. *Baggarah* were located at Shinas, while *battil* and *mashua* were recorded at Kumzar.

The *ghanjah* which in 1980 had been standing in the inlet at Sur had by 1992 disappeared. So too the stern half of a *ghanjah* which had been for many years on the foreshore at Matrah. These were to the authors' knowledge the only *ghanjah* remaining in Oman. It is regrettable they could not have been recorded prior to their disappearance. The team also did not record any *boom*, due both to their scarcity and the inaccessibility of those that were seen (as in Matrah harbour). The *shu'i* seems to enjoy relatively large numbers in Oman. The authors saw twenty-one being built at Sur, and many are actively engaged in coastal fishing. Due to their large numbers and the fact that the *shu'i* display strong western influence in design and construction, the project chose not to record their lines during the 1992 season. However, a study was made of the construction techniques and procedures being used at Sur to build *shu'i*.

In this report, vessels are grouped according to their specific type. This report does not attempt to include all of the material that was recorded, which would require several volumes. Separate monographs could be written on each type of vessel recorded. However, the authors believe this report presents a synthesis of the more important of the data.

Boat Ethnography

The basic aims of any ethnographic study of indigenous boats of a region or culture are firstly, to make a complete documentation of the vessels as they now appear: their morphology, materials, construction and function, both for use as an investigative tool and as a permanent historical record; secondly, to enable hypotheses about the forces which have contributed to their current appearance and function to be formulated, and to draw from this, inferences regarding the technical development, social structure, cultural beliefs and foreign influences which have impacted on the culture; thirdly, to develop a database of attributes and features that can be used for comparative studies.

Any national or regional style of boat building has a long tradition. For a variety of reasons, particular systems develop in regions. 'Each of these systems is handed on from one generation of shipwrights to the next with the result that each vessel produced within one building tradition is related to all the others of the same tradition. In the course of time there is a certain development in each tradition: inventions are made, constructional details from other building traditions may be incorporated, vessels may be designed for new purposes or to carry more cargo, nevertheless there is a basic system to be defined for all vessels of one tradition, which separates them from the boats of all other building traditions.' (McGrail, 1984:153). Traditional boat building practices evolve slowly, with little change from generation to generation. It is therefore possible to relate the models that are extant to their predecessors.

In analysing antecedents from the archaeological or ethnographic resource, certain spheres of study must be selected. Morphology (e.g. hull shape, rig), powering, materials, construction, function and suitability for intended purpose, as well as the sea conditions in which the vessel operated, all must be considered. Complex relationships exist among all of these.

To extrapolate from the present form of a vessel back through the evolution of that particular design, seeking origins, speculating about influences and developments, is akin to tracing the evolution of a biological species. As in biological evolution, the evolution of boat designs and construction can be seen as a concatenation of examples. However, this continuum should not be viewed as a single chain of equal links. The forces mentioned above, acting to distort or alter the gradual evolution to greater or lesser degrees, may produce dramatic changes against the background spectrum of gradual evolutionary change, somewhat as biological mutations, climatic changes or immense natural disasters may effect a species.

At times, a superficial resemblance in form may disguise the true evolutionary path. Ethnographers must be careful, therefore, not to read too much into the physical appearance of vessels, without reference to known historical facts. Hornell cites the example of the lighters used by the cotton pressers of Tuticorin. These lighters appear to have evolved directly from the plank-built canoes used in the coral trade. However, their documented evolution began with English-style square-sterned schooner-rigged lighters brought to or built in Tuticorin. These vessels proved to be unhandy when coming alongside, and a double-ended model was developed similar to the Arab *boom*, with sharply raked stem and sternpost. This model was also not satisfactory and gradually the rake of the stem and stern were reduced to the almost vertical configuration of the present lighters. The rake of the mast was also changed, from the sharp forward rake of the Arab *boom* to a mast raked slightly aft (Hornell, 1945:277).

It is therefore difficult, in the absence of numerous reliable signposts, to accurately restructure the evolutionary chain. There are however factors that can provide assistance and guidance to the ethnologist. Firstly, boat builders are a notoriously conservative lot, loathe to change their methods or materials unless forces (usually foreign influences, economic considerations, or change in the availability of suitable materials) dictate change. When change does occur, the reason for any change or innovation, particularly any rapid change, therefore must be quite powerful.

Secondly, the function of a vessel has a major influence upon its design and construction, as do the conditions under which the vessel is intended to operate. Most people are familiar with the need for cargo carrying vessels to have large cargo capacity. In recent times a need for rapid delivery of goods also developed in world trade. A good example of the result of these needs is the development in the nineteenth century of the clipper ships used in the tea, grain and wool trades, where changes in tonnage measurement rules as well as a perceived need for faster delivery times had a major impact on the evolution of those ships. The clipper ship is but one example; traditional Omani vessels also exhibit adaptations to local use and conditions.

Thirdly, the availability of certain materials for construction, their suitability for particular functions within the matrix of parts which make up any vessel, and the manners in which their physical properties effect the ways they are utilised, contribute to changes in design or in construction techniques.

Beyond these, more subtle influences such as cultural, superstitious or religious beliefs, or perhaps merely stylistic tastes, may be at work and have a pervasive effect. The knowledge and understanding a skilful boat ethnologist therefore must possess is wide-ranging, but also detailed, and includes naval architecture, boat building, comparative linguistics, materials science, archaeology, anthropology and history.

In the Indian Ocean, the study of maritime technical evolution as it relates to cultural and trade links among peoples of the region is in the early stages. Certain common features have been identified—sewn construction being the obvious example, but other clues of historical influences are perhaps more subtle and therefore difficult to discern. These subtleties are the focus of the Omani Dhow Recording Project. Being examined are the materials used, the materials processing methodology, terminology, tools, and building procedures as evidenced by features inherent in the structure.

The Programme

The Principal Investigator arrived in Oman five days prior to the official commencement date for the field work. The intention was to finalise plans and arrange logistics support already promised by several companies and organisations. Staff members and Earthwatch volunteers arrived just prior to the beginning of field work.

TEAM I

During the first two weeks Team I visited sites at Abu Al Nakheel, Al Atheiba, Al Basit, Al Maraq, Al Haradi, Al Khabura, As Suwayq, Barka, Wudam, Khawr Malah, Khawr Rasi, Mahkleef, Majis, Seeb, Shinas and Sohar (Figure 1).

TEAM II

Team II recorded vessels at Al Atheiba, Sur, Al Ashkharah, and Kumzar. In addition, Team II conducted a reconnaissance for boat types along the coasts from Sur to Ra's Al Hadd, Ad' Daffah, and south to Al Ashkharah (Figure 1).

BOAT TYPES

Unlike western sailing vessels, which are classified according to the type of rig they carry (ketch, sloop, barque, full-rigged ship, etc.) Arab boats are classified by their hull shape. As noted above, there appears to be a regional and historical fluidity in terminology. While the definitions of some types of vessel, such as the *boom*, *shashah*, *badan*, *baghlah* and *ghanjah*, appear to be universally and firmly established, others such as

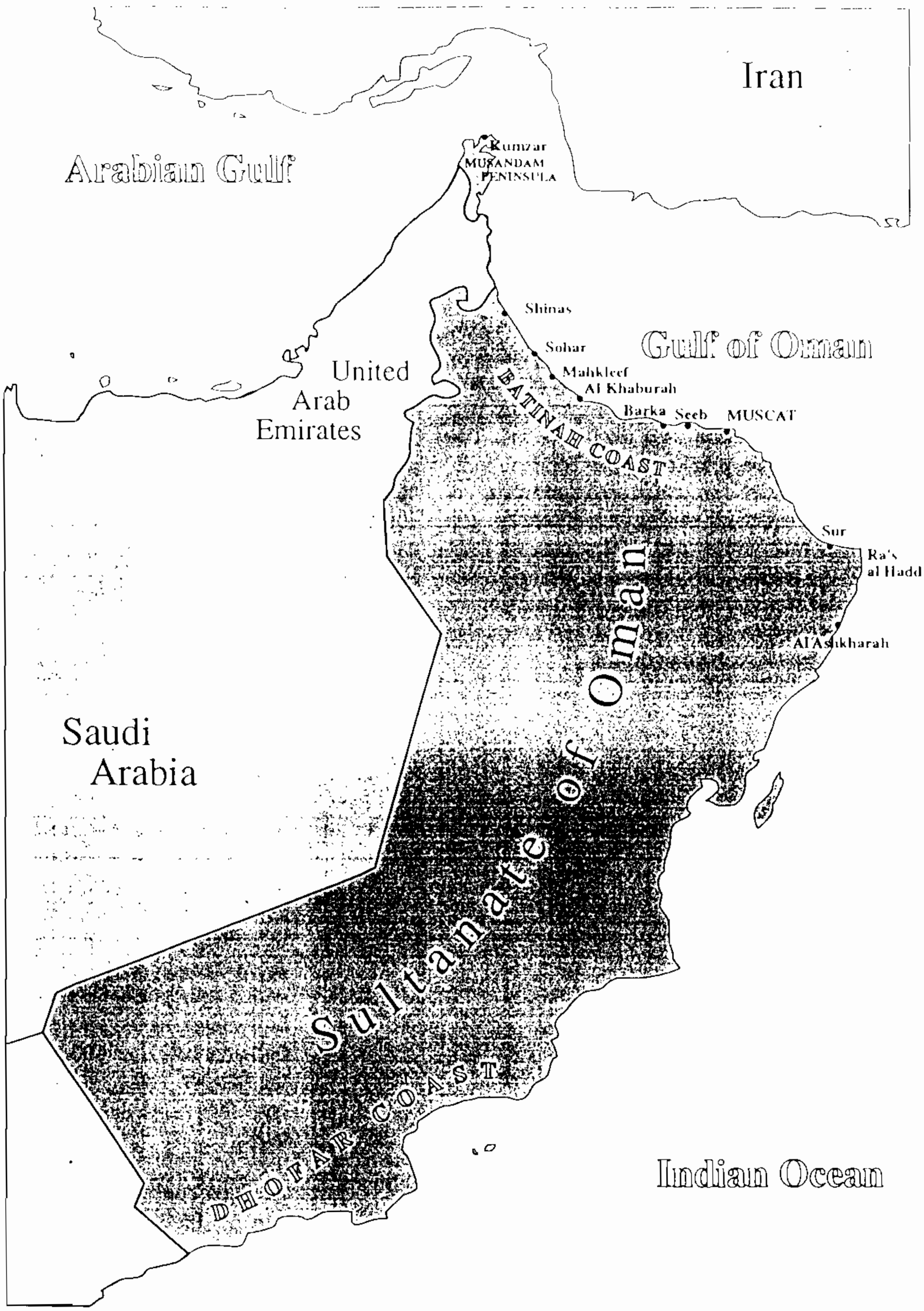


Figure 1. Map of the Sultanate of Oman

the *zaruk*, *battil*, *mashua*, and *houri* vary both temporally and regionally.

BADAN

Along the Batinah coast north of the capital Muscat, Team I located many vessels of the type known as *badan*. The design of the *badan* is characterised by a thin planked beak head and a high pointed stern fin sewn to the hood ends of the planking. The classic *badan* is both a sailing and rowing vessel, having one or two masts and usually five rowing positions (Figure 2). All the *badan* examined by the research team had only one mast position, and in each case the mast was missing, but the mast partner beam and mast step identified the *badan* as a sailing vessel. The presence of thole pins or supports for them indicated these vessels were also used for rowing. As with all the Omani rowing vessels except the *shashah* recorded in the 1992 season of field work, the *badan* is rowed by men sitting on the gunwales facing athwartships. The thole pin for each rowing position is situated well aft on the same side as the rowing position.

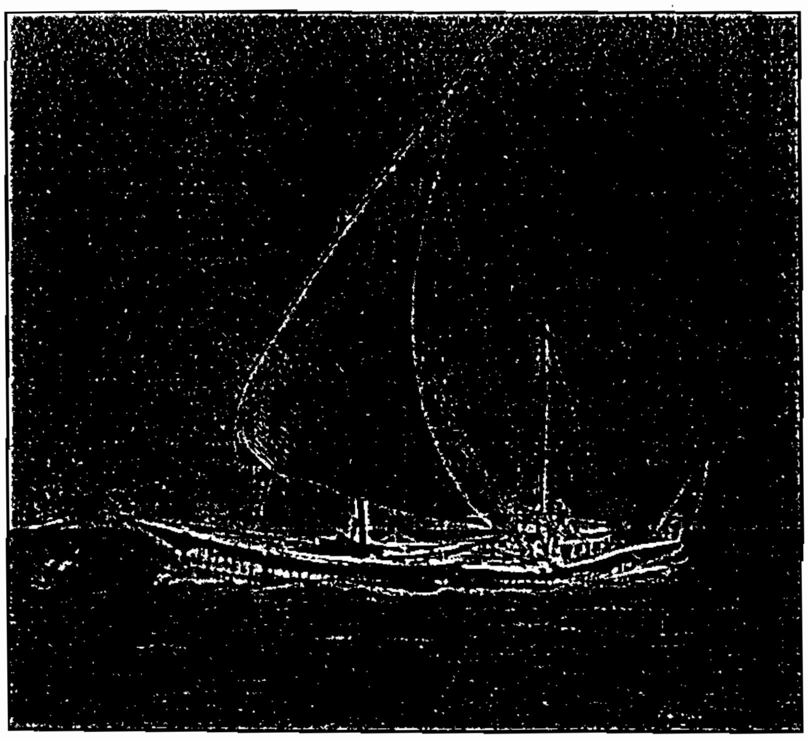


Figure 2. Badan *sailing off Muscat, 1970*

KM1: a *badan*

Location: at the central part of the Khawr Malah beach, where there is a gap in the waterfront row of houses, not far from a town square with a full-scale boat model of a *badan*.

Length: 13550

Maximum beam: 2390 (2475 with the wales)

Accuracy of measurement: dimensions ± 10
scantlings ± 2

General description:

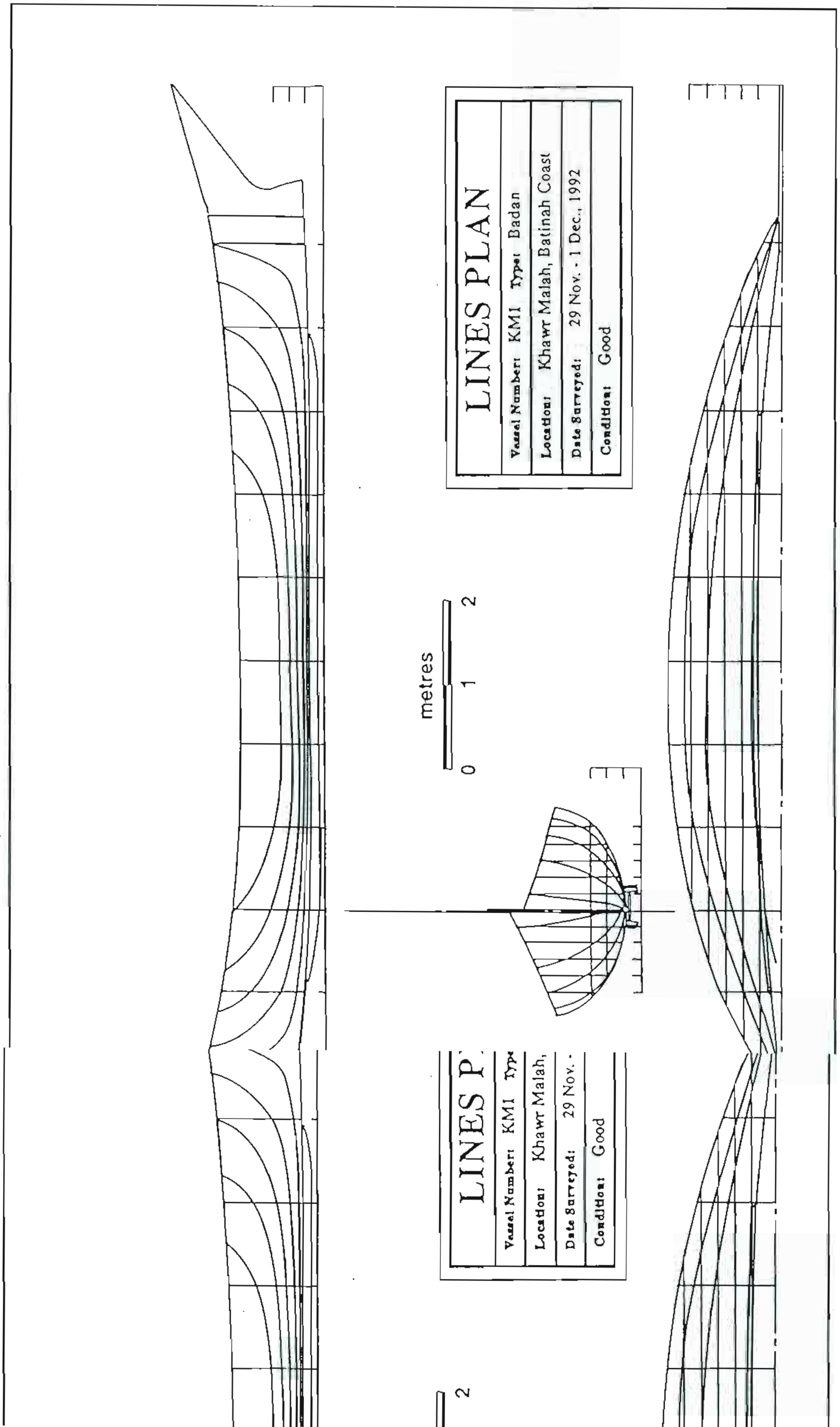
The *badan* is doubled-ended, with relatively slack bilges, a fine entry and easy run aft (Figure 3).

This *badan* is hauled up on the beach, its bow facing seaward. It maintains its upright position without support by shores thanks to its twin 'grounding keels' or skegs. It is in good condition; at the time of recording it was obvious that it had been recently smeared with resin or fat. It has an open hold with partial decks at bow and stem.

The bottom comprises a keel plank rather than a true keel and a skeg or grounding keel on either side of the keel plank running along most of the length of the vessel.

The stem is rabbeted to receive the hood ends. It is reinforced by a much heavier timber, an apron, set inboard of the stem and bolted to it with at least one fastener, round-headed on the outside and with a square rove inboard. This bolt shows on the outside of the hull, at a height of 660 mm from the bottom. Attached to the forward face of the stem is a planked beak.

The beak consists of four planks, joined with nailed scarfs of the lap joint type. The nails are driven in from either port or starboard and clenched on the opposite side. In addition three iron staples are



badan *KM1, at Khawr Malah.*

driven in at intervals. Finally, a number of plugged holes, spaced at regular intervals along the edge of the plank directly forward of the stem, may indicate that this timber was previously laced to the stem or that it is a re-used piece from another vessel, entirely or partially laced.

The fasteners between stem and beak comprise only two nails, driven obliquely from the beak plank (one from either side) into the stem. The beak planks are sandwiched at their upper edge between two long curved timbers called cheek knees that run from the sides of the foredeck to the foremost beak plank as extensions of the wales. The cheeks are fastened with round-headed nails. Further down another pair of cheeks runs from the bow to the foremost edge of the beak planks. They are fastened to the bow planking, the stem and the beak planks with round-headed nails. The starboard cheek knee is fastened to the bow planking and to the stem with the standard large round-headed nails. The port cheek knee is fastened to the same elements with much smaller nails. Forward of the stem two large nails are driven through both cheeks and the plank between them and clenched on the opposite side.

The sternpost is vertical with a planked fin attached to it. Two pairs of cheeks run parallel from the stern planking along the fin and project slightly beyond it forming two notches, upper and lower. The forward edge of the rudder would fit in these notches, an arrangement that allows the rudder to turn within the notches and at the same time restricts it and prevents it from slipping out of position. The upper cheeks of the tail are extensions of the caprails (and wales) while the lower cheeks are relatively short and light in section. The rudder was not in place at the time of recording.

area below the partners. It comprises thirty-eight frame stations numbered from bow to stern. Scantlings vary significantly from one framing timber to the next. Spacing averages 270-280 mm centre-to-centre. The frames are nailed to the planks with round-headed nails driven from the outside and clenched on the inboard surface of the frames. Additional nails are driven in areas with repairs. At the bow several repairs render the nailing pattern, as it appears on the outside, irregular.

Frame station No. 1 comprises paired half-frames. At their lower ends long nails are driven athwartships through both framing timbers. Frame station No. 2 is a very short floor spaced in the middle of what would be a standard interspace between frames No. 1 and 3. Aft of the floor at frame station No. 6 is a drain hole with a tall stopper. Thole pin cleats are located up the sides of the hull in the narrow space between frames just below or behind the stringer. In some cases they extend from one framing timber to the next; they are always next to at least one (thole pin cleats at: port No. 9 forward, 13 forward, 17 forward, 21 forward, 25 forward, 28 aft; starboard No. 13 forward, 17 aft, 21 forward, 25 forward, 28 aft, 29 forward).

Some frames have their upper end notched into rectangular openings in the caprail, as is the case at frame station No. 10 on the port side. Frame station No. 35 comprises a floor, very thick at the throat and with a limber hole cut in the middle of its underside. It is not certain if this is the only floor with a limber hole.

In addition to the rectangular openings (six starboard and four port) for the ends of frames the caprails exhibit squarish openings for thole pins

beak planks are sandwiched at their upper edge between two long curved timbers called cheek knees that run from the sides of the foredeck to the foremost beak plank as extensions of the wales. The cheeks are fastened with round-headed nails. Further down another pair of cheeks runs from the bow to the foremost edge of the beak planks. They are fastened to the bow planking, the stem and the beak planks with round-headed nails. The starboard cheek knee is fastened to the bow planking and to the stem with the standard large round-headed nails. The port cheek knee is fastened to the same elements with much smaller nails. Forward of the stem two large nails are driven through both cheeks and the plank be-

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wales and clenched onto their underside. The wales are also fastened to the frames, with nails driven in horizontally from the outside and clenched on the inboard surface of the frames.

The stringers are nailed to each frame with a single nail. The nails are arranged in a staggered pattern along the length of the stringers. The pattern is broken at places; for example at frame station No. 9 on both sides there is an overlapping joint between two pieces of stringer that are nailed to each other and to the frame with three nails on the port side and two on the starboard side.

The foredeck is supported on four beams, at least two of which rest in notches on the stringer or beam shelf. The main beam is particularly heavy and is rabbeted to take the deck planks. Its ends project beyond the sides of the hull, through notches in the upper edge of the top strake. The sides of the deck planking, notched at places to accommodate the ends of frames, stop short of the hull planking and are clamped down by the caprail on the starboard side while on the port side a long timber (longitudinal filler) fills in the space between deck and caprail. The maximum length of the deck plank along the centre-line is 1895 millimetres. A cross bitt is located far forward at the bow. Its ends project beyond the sides of the hull and are carved into ogee shaped finials.

The two beams forward of amidships are identified as mast partners although we could not confirm the presence of a mast step or traces of it below them due to the masses of nets stored in the hold. The beams are connected by two carlings running on either side of the centre-line at an angle. The carlings are rounded in section along

ping joint between two pieces of stringer that are nailed to each other and to the frame with three nails on the port side and two on the starboard side.

The foredeck is supported on four beams, at least two of which rest in notches on the stringer or beam shelf. The main beam is particularly heavy and is rabbeted to take the deck planks. Its ends project beyond the sides of the hull, through notches in the upper edge of the top strake. The sides of the deck planking, notched at places to accommodate the ends of frames, stop short of the hull planking and are clamped down by the

lodging knee on either side keeps the forward partner firmly in place. One arm is nailed to the after face of the partner; the other is nailed to the stringer. The space between the partner and the caprail is filled in with a small blocking. The after partner is lighter in dimensions and fitted into notches in the stinger only.

A beam across the after part of the open hold rests on the stringer. Abaft this beam and immediately forward of the afterdeck main beam a wide beam or thwart appears to have been added as an afterthought.

The afterdeck comprises eleven deck planks nailed on five deck beams. It is 2.15 metres long on the centre-line. The main beam is rabbeted to take the deck planks. Like the foredeck main beam, it has its ends projecting beyond the sides of the hull through notches cut in the upper edge of the top strake. An inwale runs along both sides of the deck. At its after end two stanchions are stepped in circular openings in the caprails and carry a gallows at their upper ends.

A large number of wooden dowels shaved flush with the exterior planking surface, are visible on the sides of the hull. They are driven through the thickness of the planking or at an angle so that they run through seams between adjacent strakes. The dowels driven through the planks appear to be merely plugging holes, as they are not fastening any structural member to the planking. Often they are arranged in corresponding pairs on either side of a seam. This configuration perhaps indicates that the holes plugged by the dowels were originally drilled during the building of the boat's shell so that adjacent strakes could be fastened temporarily with lashings. The others, driven obliquely through the plank seams, are

forward of the afterdeck main beam a wide beam or thwart appears to have been added as an afterthought.

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Of the many *badan* noted, this KM1 and AT8-B (from Al Atheiba) were documented in detail, with lines being taken, construction recorded and photographs taken. A third (KM2)was recorded photographically and with brief notations and general measurements.

The beach at Majis provided many examples of vessel design in transition. Several boats—both *badan*, *houri* and 'lanshes'—had been modified to take advantage of outboard motor power. These vessels, originally double-ended sailing and rowing boats, had been modified by cutting off the stern and fitting a transom on which to mount an outboard motor. At least one of the vessels, a *badan* (MA7), also had the bow modified, the original beak and stem post having been sawn off and replaced with a curved stem. To illustrate the modifications of the bow, the research team temporarily mounted the cut-off section of the original bow to the modified bow (Figure 4). It is not known whether this modification is due strictly to handling considerations and is therefore a hydrodynamic advantage, or if it is stylistic. Although bow overhang would increase the tendency of the vessel to ride over seas, rather than plough through, this change in design may also be for cultural, rather than purely hydrodynamic reasons. Some contemporary Indonesian vessels, when modified for engine power, also have hull modifications done, not for hydrodynamic reasons, but merely as a visual announcement that the vessel now has mechanical power (Burningham, personal communication, 1993).

to take advantage of outboard motor power.. These vessels, originally double-ended sailing and rowing boats, had been modified by cutting off the stern and fitting a transom on which to mount an outboard motor. At least one of the vessels, a *badan* (MA7), also had the bow modified, the original beak and stem post having been sawn off and replaced with a curved stem. To illustrate the modifications of the bow, the research team temporarily mounted the cut-off section of the original bow to the modified bow (Figure 4). It is not known whether this modification is due strictly to handling considerations and is therefore a hydrodynamic advantage, or if it is stylistic. Although bow overhang would

Both the discarded beakhead of the bow and stern structure cut off this *badan* had been preserved by the owner. With his permission, the team dissected the stern structure of the vessel, gaining many insights into the hidden joinery. It was noted that the joint of the stem post and hood ends was particularly unusual, the hood ends being tapered and slotted into a deep V-shaped rabbet cut in the sternpost. This configuration had the advantage of dispensing with the need for fastenings near the ends of the plank, where they might cause splitting.

MA3: a *badan*
Location: in a *barasti* close to MA1 and MA2, but further away from the water.
Length overall: 11350
Maximum beam:
General description:
This vessel is a *badan* with the typical planked beak attached at the bow and two skegs or grounding keels instead of a true keel. Its stern is modified into a roughly triangular transom to mount an outboard motor. The top strakes run beyond the transom, forming wing-like projections. There are no wales. The caprail has rectangular openings for the ends of frames and square openings for thole pins. The cross bitt at the bow is carved with elegant ogee-shaped tips.

MA7: a *badan* stern
This piece of a *badan* stern comprises the whole planked tail, the sternpost and the ends of planking strakes. The owner sawed the stern off his vessel, probably with the intention of creating a transom or stern mount for an outboard engine. At the time of recording the piece was lying in his backyard and it is not clear whether he intended

rabbet cut in the sternpost. This configuration had the advantage of dispensing with the need for fastenings near the ends of the plank, where they might cause splitting.

MA3: a *badan*
Location: in a *barasti* close to MA1 and MA2, but further away from the water.
Length overall: 11350
Maximum beam:
General description:
This vessel is a *badan* with the typical planked beak attached at the bow and two skegs or grounding keels instead of a true keel. Its stern is modified into a roughly triangular transom to

The sternpost is a straight, vertical timber. It is rabbeted to take the hood ends, which, as mentioned earlier, are bevelled to fit into a V-shaped rabbet (Figure 5). Set against the forward face of the sternpost is a heavy vertical timber or apron. Both sternpost and apron exhibit a large circular hole drilled vertically through the centre of their underside. This hole reveals the method by which the two timbers were fastened to the keel, obviously involving a large bolt driven from underneath.

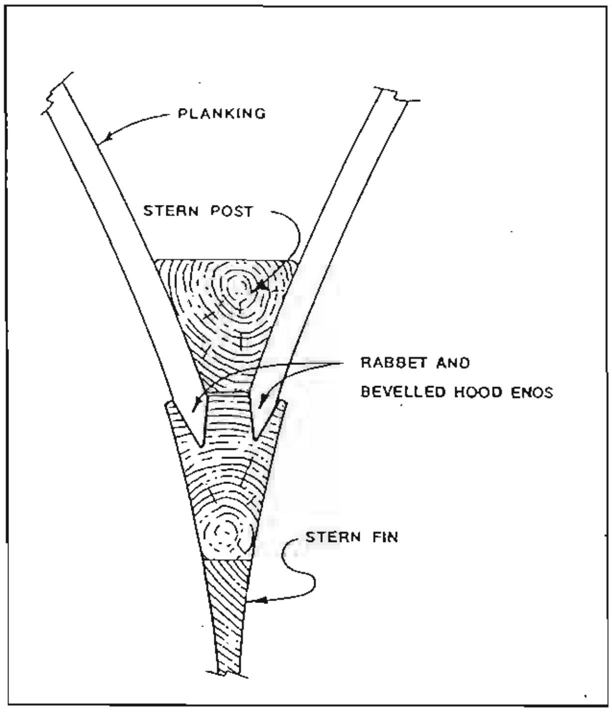
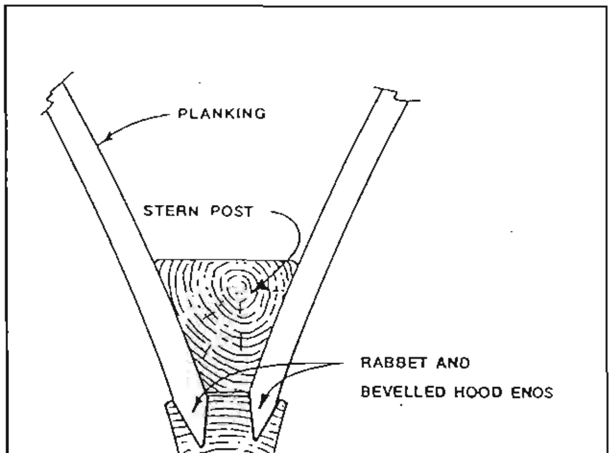


Figure 5. V-shaped rabbet in sternpost.

The tail fin does not have its high vertical tip, which has been sawn off. The tail planks are held together by cheek knees, upper and lower. As in any *badan*, the upper cheek knees are probably extensions of the caprails or the wales and project neath.



into the sternpost rabbet with double-bevelled hood ends. They are fastened to the apron and to the aftermost frame with round-headed nails driven from the outside. A large number of wooden dowels are visible on the planking surface. Most of them are driven straight through the planking and are apparently plugs for disused holes. Two dowels are driven obliquely through a seam. One has its end shaved flush with the planking surface. These dowels driven obliquely between seams were very common on all the *badan*, *battil* and *mashua* recorded. They are used to keep the edges of planks aligned as these vessels are planked up.

A number of samples, of wood and dowels, were taken:
Samples No. 12, 13: wooden dowels
Samples No. 14, 23: wood samples

Majis boat count: several *shashah*, three dugout *houri* with a counter stern, planked *houris* and *badan*; we looked at six planked *houri* (five transomed and one double-ended), one *badan* and the sawn-off stern of another.

At Al Atheiba, a beach north-west of Muscat, south-east of Seeb airport, a number of vessels were examined

Al Atheiba boat count: Thirty-eight *houri* and seventeen *badan*. Of these, one *badan* (AT8-B) was documented in detail, while general dimensions and descriptions were made of the other *badan* and of twenty of the *houri*.

AT1-B, a *badan*
Location: western end of the beach
Length overall: 12440
Maximum beam: 2360

between seams were very common on all the *badan*, *battil* and *mashua* recorded. They are used to keep the edges of planks aligned as these vessels are planked up.

A number of samples, of wood and dowels, were taken:
Samples No. 12, 13: wooden dowels
Samples No. 14, 23: wood samples

Majis boat count: several *shashah*, three dugout *houri* with a counter stern, planked *houris* and *badan*; we looked at six planked *houri* (five transomed and one double-ended), one *badan*

The hood ends of the plank strakes are stitched. In keeping with the usual framing pattern, this vessel has two pairs of filler, or 'half-frames' aft of the mast step floor.

AT2-B, a *badan*
Location: All of the *badan* examined at Al Atheiba are numbered proceeding from left to right (facing the sea).
Length overall: 9780 from forward extremity of the beak to the stern rabbet, where the fin has been cut off.
Maximum beam: 2040
Accuracy of measurement: dimensions ± 5
General Description:
This vessel is in very poor condition. The stern fin has been removed. There are twenty-nine frame stations of which eleven are floors with the usual double pair of filler frames aft of the mast step floor. There is a small deck forward, planked athwartships. There are five heavy thwarts, of which the first, fourth and fifth are through-beams. The mast partner beam apparently has been replaced, as there is no semi-circular notch for the mast, but a mast step is preserved. There are two thole pin sockets in the port caprail and three on the starboard.

AT3-B, a *badan*
Length overall: 10320
Maximum beam: 2300
Accuracy of measurement: dimensions ± 5
General Description:
Very poor condition. Missing both the beak and the tail fin. There are thirty-four frame stations, the usual double pair of filler frames aft of a very heavy mast step. Remains of a small athwartships planked deck in the bows was noted. There are three through-beams. The caprail has three holes for thole pins on each side.

the beak to the stern rabbet, where the fin has been cut off.
Maximum beam: 2040
Accuracy of measurement: dimensions ± 5
General Description:
This vessel is in very poor condition. The stern fin has been removed. There are twenty-nine frame stations of which eleven are floors with the usual double pair of filler frames aft of the mast step floor. There is a small deck forward, planked athwartships. There are five heavy thwarts, of which the first, fourth and fifth are through-beams. The mast partner beam apparently has been replaced, as there is no semi-circular notch for the mast, but a mast step is preserved. There

and hull. There are thirty-four frame stations, with two pairs of fillers aft of a heavy mast step. Three through-beams, the mast partner beam is heavy. Thole pin pads are fitted to the caprail, three on each side. There is a small aft deck, with covering boards.

AT5-B, a *badan*
Length overall: 11670
Maximum beam: 2040
Accuracy of measurement: dimensions ± 5
General Description:
Very poor condition. The aft deck is mostly constructed from plywood and there is the usual athwartships-planked small foredeck. The mast partner beam and mast step are very crude, followed by the expected pattern of two pairs of filler frames. The lower cheeks of the fin have been by a light cleat nailed to the port side of the fin and the hull.

AT6-B, a *badan*
Length overall: 10180
Maximum beam: 2030
Accuracy of measurement: dimensions ± 5
General Description:
Very poor condition, with the fin missing. No decks are preserved. The hood ends are stitched. There are thirty frame stations with a double pair of fillers or half-frames aft of a heavy mast step. The mast partner beam is heavy as well.

AT7-B, a *badan*
Length overall: 11570
Maximum beam: 2080
Accuracy of measurement: dimensions ± 5
General Description:
In reasonable condition, this vessel has a rudder shipped. It has thirty-four frame stations and double pair of fillers aft of mast step. There is a

Accuracy of measurement: dimensions ± 5
General Description:
Very poor condition. The aft deck is mostly constructed from plywood and there is the usual athwartships-planked small foredeck. The mast partner beam and mast step are very crude, followed by the expected pattern of two pairs of filler frames. The lower cheeks of the fin have been by a light cleat nailed to the port side of the fin and the hull.

AT6-B, a *badan*
Length overall: 10180
Maximum beam: 2030
Accuracy of measurement: dimensions ± 5

AT8-B, a *badan*

Location: between two concrete-floored *barasti* in front of a bright pink and white house. A circular, crenellated building stands behind it.
Length overall: 10280
Maximum beam: 2040
Depth of hold: 1580-1540 (amidships)
Accuracy of measurement: dimensions ± 5
scantlings ± 2

General description:
The vessel looks old and rather neglected. Some of its elements, such as the decking at the forward part of the hold and the plywood foredeck, seem to have been inserted as afterthoughts; repairs are common. The timbers are greyish in colour and have not been oiled recently. The hold is littered and dusty. Considering the fact that the vessel has obviously not been used for quite some time, it comes as a surprise that the rudder is still in hung on the stern fin, the thole pins are still firmly in place and all oars shipped. There were large disc-shaped discolorations on either side at the bow, indicating where a number had been attached to the hull. It was said by the owner that the number had been fixed when the vessel was competing in races, apparently an annual event.

In shape the vessel is a typical *badan*, double-ended with a pointed beak and a high stern fin attached to the almost vertical ends (Figure 6). The most remarkable feature of the structure is that the hood ends at bow and stern are fastened by lacing instead of nails, a characteristic shared by all the Atheiba vessels of the *badan* type.

The stem post does not show on the exterior of the hull. The hood ends from each side meet and are fastened together by lacing, but at least one nail is driven across the joint through the converging hood ends of the top strakes. The planked beak is attached to the vertical joint, also by lacing. On the outside the lacing (single rope) passes in crisscross pattern over a strip of fibrous wadding. This may be inserted to protect wood and rope from wear, but certainly as a ground on which to 'harden up' the lacing and to help prevent water's leaking through the joint. The beak is held in place by a single pair of cheek knees that start abaft the ends of caprails near the bow on the outboard surface of each side. They are fastened in place by nails. The beak is narrow at its lower part and does not carry lower cheek knees.

The stem is of similar design with the hood ends fastened with lacing and the planked stern fin laced to this joint. The fin consists of a vertical plank laced to the stern and followed by near-vertical planks laid edge-to-edge at a slight angle, an arrangement that gives the entire tail its slight rake. The tail planks rise progressively higher to form a fin extending high above the afterdeck. 'Step' joints, to prevent the fin planks sliding out of alignment are visible. The aftermost and highest plank has a squared tip with a notch at its forward edge for hanging the rudder. Plastic-coated wire stitches run hold this plank to the one forward of it. Two pairs of cheek knees, upper and lower, are fastened along either side of the tail surface, with their ends projecting aft. The upper pair begins at the point where the caprails end, but is fastened to the exterior surface of the planks. The lower pair consists of short splines fastened to the fin planks with plastic cord lacing.

The planking each side consists of seven strakes and two stealers—one wide top strake, supplemented by stealers fore and aft fitted above the top strake, a garboard and a first broadstrake, with four drop strakes fitted between the first broad and the top strake. At intervals, dowels are driven obliquely from near the edge of one plank, through the faying surfaces of the plank seam and into the adjoining plank. These are located between frame stations. As is common with vessels of the region, as well as in parts of south-east Asia, conceptually the hull seems to be of two distinct parts, a lower hull comprising garboards and drop strakes and an upper hull of wide sheer strake and stealers to lift the sheer line in the ends.

As has already been mentioned, the rudder is still in place, at the time of recording strapped to one

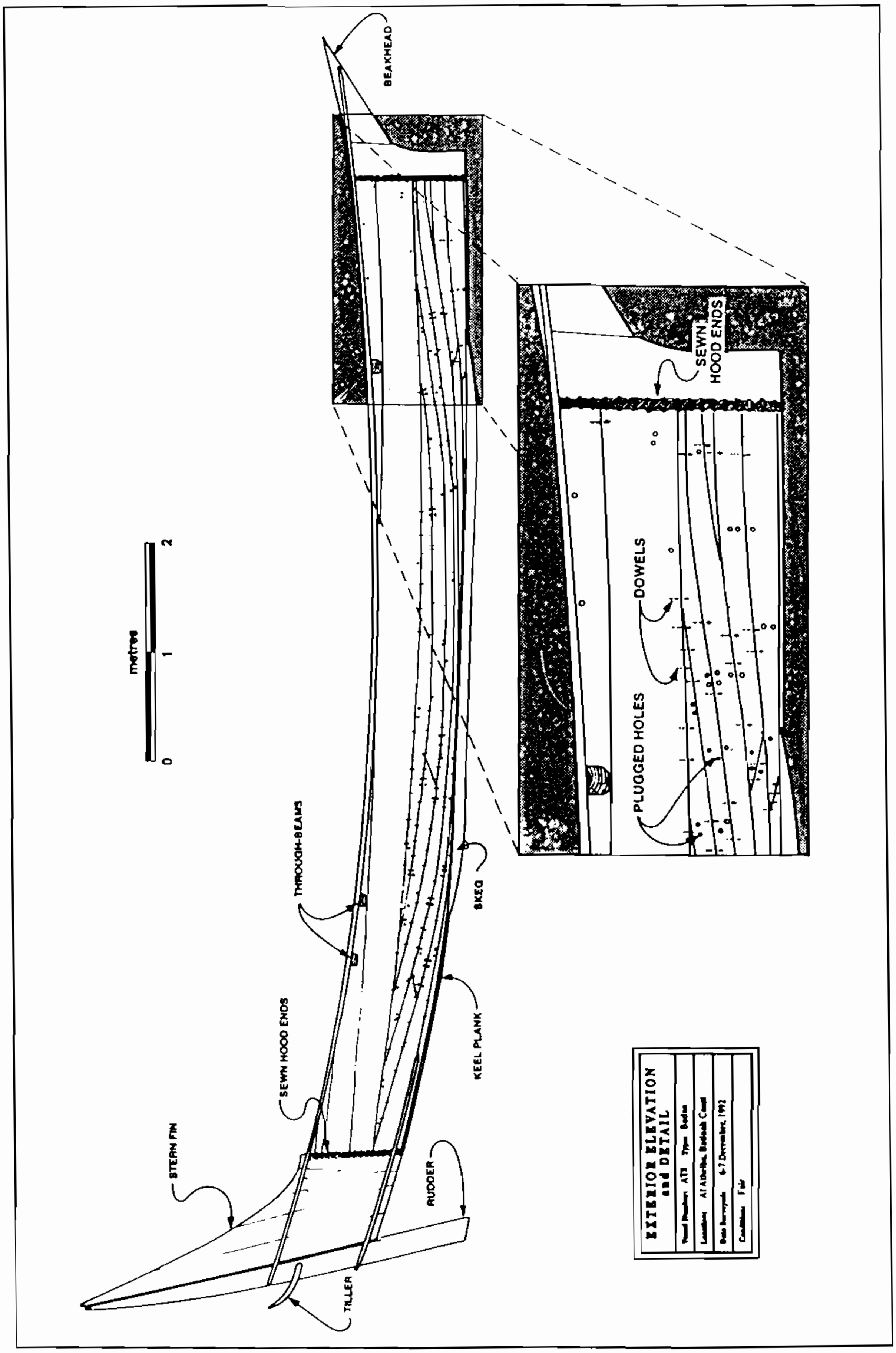


Figure 6. Exterior construction elevation of badan *AT8.*

side of the hull. To demonstrate its normal position the research team set it in its normal position abaft the stern fin. Being very high and narrow, it has a very high aspect ratio. Its high aspect ratio would tend to generate lift and is an obvious aid to sailing performance. When in use, its forward edge fits into the open notches formed by the projecting ends of the stem fin cheek knees. A rope grommet in its upper tip drops into a slot in the top of the stem fin. Held in place by the steering ropes running to either side, and possibly by a tackle as illustrated in the photo of a *badan* sailing off Muscat in 1970 (Figure 2), the rudder is not allowed to slip out of this position but may still be steered to different angles.

The foredeck has been replaced by a plywood platform wedged between the sides of the bow. The plywood is nailed to the beam shelf on either side. It begins 25 mm aft of the bow apex line and ends forward of frame station No. 3 on the starboard side and just aft of frame station No. 4 on the port side. Its maximum length on the centre-line is 1135 millimetres. Further aft, a beam does not rest on the beam shelf but in notches cut in the top strake. Its ends protrude beyond the sides of the hull by 130-135 mm.

A rudimentary deck covers the area between the foremost beam described and the forward partner. Ten deck planks are nailed to two fore-and-aft timbers and to the stringers with small nails. The fore-and-aft timbers run at an angle to the centre-line towards each other and are lashed onto the underside of the forward partner and of the foremost beam.

Two beams aft of the rudimentary deck structure are identified as mast partner beams. They simply rest on the beam shelf. The forward beam has a semi-circular notch cut in the middle of its after edge, presumably where the mast would rest. The floor slightly abaft the forward beam (frame station No. 13) has its throat carved into a rectangular athwartships mast step. The socket for the heel of the mast is circular.

A single beam is laid across the after part of the open hold. It rests on the beam shelf and its ends project beyond the sides of the deck through openings in the top strake. The starboard end is sawn flush with the planking surface.

The afterdeck rests on five beams. Three of these rest in notches cut in the beam shelf, while the other two including the main beam, simply rest on the beam shelf. The port end of the main beam protrudes through an opening cut in the top strake; the starboard end also rests in a similar opening but is sawn flush to the exterior surface of the planking. The main deck beam is rabbeted to take the deck planks. A capping or narrow strip of wood is nailed onto the forward edge of the deck beam. Deck planks are nailed to the beams. Nails are very corroded and both deck planks and deck beams are in poor condition. The sides of the deck are lined by inwales that cover the space between the deck and the caprails.

Framing consists of thirty-two frames arranged, for the most part, in the typical pattern of alternating floors and paired half-frames. The four foremost and four aftermost frame stations, and two frames abaft the forward mast partner break this regular pattern; they all comprise successive pairs of half-frames. The four foremost half-frames are doubled by small side pieces and, in one case, (frame station No. 2) by a short floor, inserted between stations. All floors have limber holes. The centre-to-centre spacing of frames averages 270 mm to 280 mm but is fairly irregular and ranges between 240 mm and 320 mm.

The outboard edges of the caprails are flush with the exterior surface of the planking. The starboard caprail consists of three pieces, while the port caprail consists of five. The pieces are joined with diagonal and stepped scarfs or simple butt joints. The caprails have rectangular openings into which the notched ends of frames are fitted. Squarish openings in the caprails are designed to take the thole pins and are sometimes mounted by an additional block or rowlock pad. Further down the sides of the hull thole pin cleats with similar square holes are wedged between frames and secure the lower part of the thole pin.

The beam shelves are square-sectioned timbers fastened to the frames with one nail per frame. Apart from the three aftermost deck beams of the afterdeck, beams are not set in notches cut in the shelf but simply rest on its upper face.

Just as noted on the *badan* KM1, a large number of wooden dowels, shaved flush with the exterior planking surface, are visible on the sides of the hull. It is presumed that as in KM1 they are relics from the building procedure. Their number and distribution therefore deserve intense study, as they would likely provide valuable information about the construction method. Also evident on the outside of the hull planking are numerous holes plugged with small dowels. These dowels are redundant and the holes they plug are apparently relics from the construction process, perhaps for lashings to secure strakes during the planking process. The pattern of plugged holes and edge-joining dowels says a great deal about the building procedure. In this illustration (Figure 6), the positions of the plugged holes are represented by small circles and the dowels by short straight vertical lines. It would appear that the dowels were used to lock the alignment of the plank edges during construction before the fitting of frames. The plugged holes were either for temporary lashings or holes from where temporary external frames were nailed prior to the fitting of permanent internal framing. This system of temporary external framing is common in Arab boat building.

There were six oars shipped, all with square blades lashed to the looms (Figure 7).

AT9-B, a *badan*
Length overall: 11540
Maximum beam: 2130
Accuracy of measurement: dimensions ± 5
General description:
This *badan* with thirty-two frame stations and the usual double pair of fillers aft of the mast step is in fair condition. There are thole pin pads nailed to the caprail, three each side, staggered in their positions. The mast step and partner beam appear heavy. There are decks fore and aft as in most of the previous *badan* recorded.

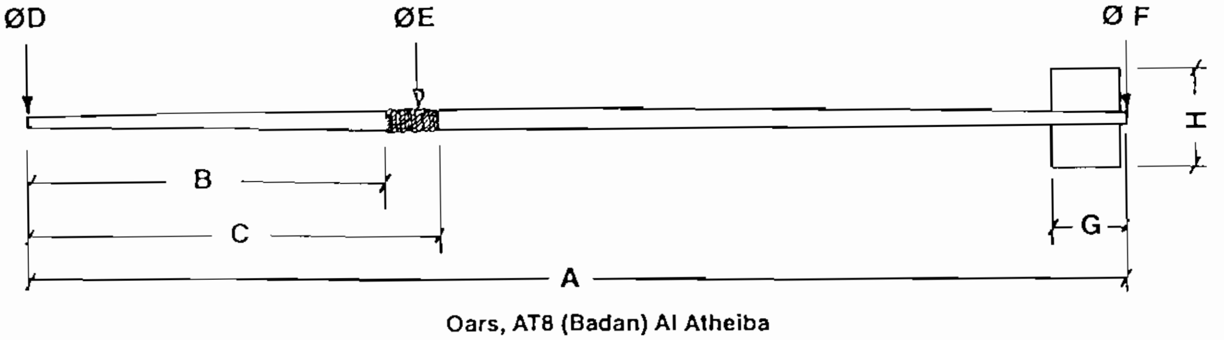
AT10-B
Length overall: 10950
Maximum beam: 2190
Accuracy of measurement: dimensions ± 5
General description:
A *badan* in very poor condition. There are thirty-two frame stations, with double fillers aft of the heavy mast step. There are remains of an aft deck with covering boards, but the stern fin is missing. In addition to the heavy partner beam, there are three through-beams.

AT11-B
Length overall: 11370
Maximum beam: 2000
Accuracy of measurement: dimensions ± 5
General description:
This *badan* is in fair to good condition. The usual pattern of framing with thirty-two frame stations. Three through-beams, plus a mast partner beam.

AT12-B
Length between perpendiculars: 8950
Maximum beam: 2100
Accuracy of measurement: dimensions ± 5
General description:
In very poor condition. Beak one metre long.

AT13-B
Length between perpendiculars: 9180
Maximum beam: 2030 (estimated)
Accuracy of measurement: dimensions ± 5
General description:
Extremely poor condition. The back is broken, the hull extremely distorted. In contrast to the other *badan* on the beach, this one does not exhibit the double pair of filler frames aft of the mast step floor. If the condition of this vessel in comparison to the others is an indication of its age, the difference in framing pattern may indicate an evolutionary change in building design.

AT14-B
Length between perpendiculars: 8490



OAR No.	Dimensions (in millimetres)							
	A	B	C	D	E	F	G	H
1	4830	1560	1820	24	85	67	300	430
2	5890	1950	2220	50	80	50	300	430
3	6530	2000	2350	50	80	80	400	300
4	4820	1550	1840	50	85	60	400	300
5	5140	1530	1720	50	85	60	430	360
6	4220	1290	1550	50	70	50	380	310

Figure 7. Oars of badan AT8, with table of sizes.

Maximum beam: 2090
Depth of hold: 0.770, gunwale to top of keel plank
Accuracy of measurement: dimensions ± 5
General description:
Poor condition. The usual arrangement of elements.

AT15-B
Length between perpendiculars: 9650
Maximum beam: 2075
Depth of hold: 0.780
Accuracy of measurement: dimensions ± 5
General description:
Fair to good condition.

AT16-B
Length between perpendiculars: 9350
Maximum beam: 2125
Depth of hold: 0.750
Accuracy of measurement: dimensions ± 5
General description:
In fair condition.

AT17-B
Location: This *badan* is at the extreme north end of the beach. It was not noticed until after the others had been documented and due to its position on the beach should have been labelled 'AT1-B'. It was not measured.

Cargo *badan*
At Mahkleef was found the hulk of what was apparently a cargo *badan* (*'uwaissiyyah).* Four *'uwaissiyyah* were also found drawn up and clearly out of service on the beach at Al Ashkharah. The main distinguishing feature of these cargo *badan*, when contrasted with the fishing *badan* of the Batinah coast, is size. The beak and stern fin are very similar to their smaller cousins.

MK1: Remains of a cargo *badan* (*'uwaisiyyah*)
Location: Outside the unnamed mosque just south-east of Majama mosque at Mahkleef.
Length: 11570 mm between perpendiculars
Depth: 1750 mm (maximum)
Accuracy of measurement: dimensions ± 20
scantlings ± 2
General description:
In very poor condition, the vessel was said by bystanders to have been built at Sur about fifty years ago (Figure 8). Both the beakhead and the stern fin had been removed. Heavily built, hard-

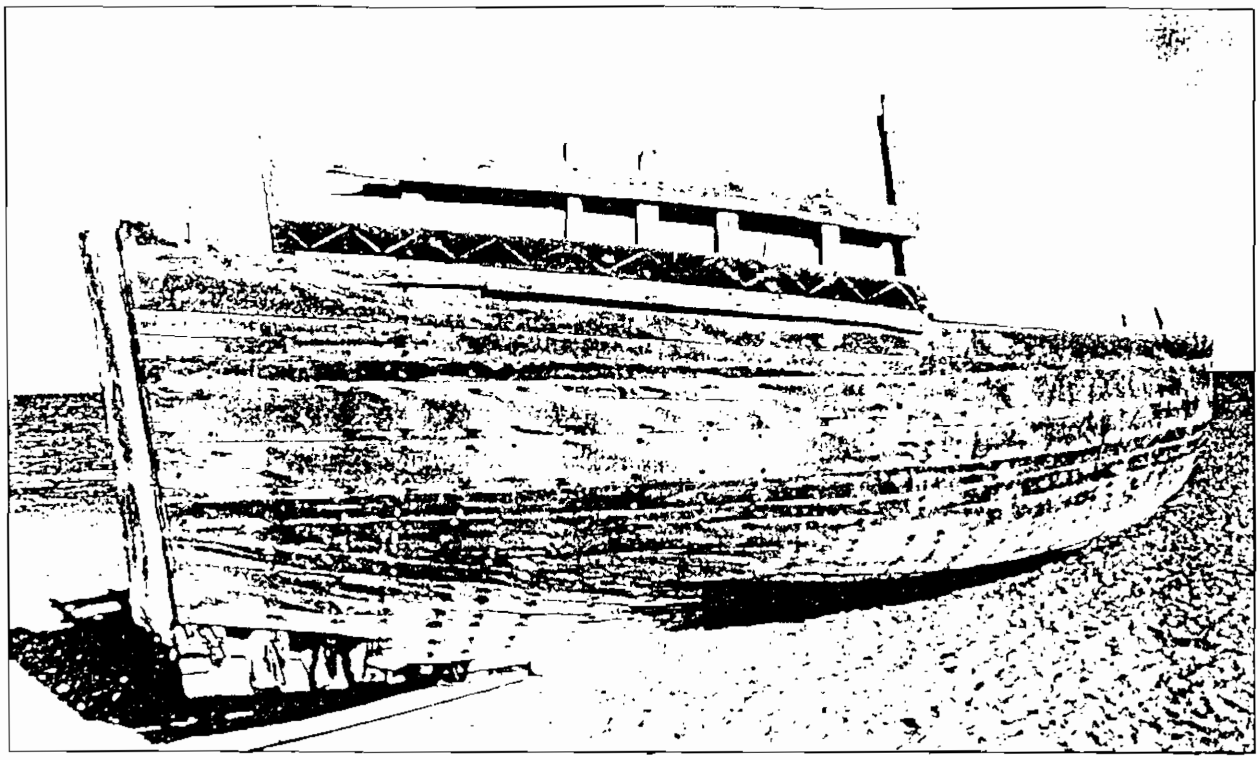


Figure 8. Hulk of cargo badan ('uwaisiyyah) *at Mahkleef. The stern fin and beakhead have been removed.*

bilged and double-ended, the hull exhibited the typical planking pattern seen on other *badan*. In common with the smaller fishing *badan*, but in contrast to the cargo *badan* found at Al Ashkharah, this vessel had twin skegs. Unusually, the hull had three sets of bilge stringers in addition to the beam shelves (Figure 9). The presence of bilge stringers may be a function of the relatively large size of this vessel as compared to the fishing *badan*. However, the even larger *'uwaissiyyah* recorded at Al Ashkharah had no stringers at all. It is thought the use of bilge stringers may be a western influence. The stringers were fastened to every other frame (each half-frame) by iron nails. There was no deck and it was unclear if any substantial decking had ever been present. Certainly, few deck beams were noted. However, notches in the beam shelf forward indicated there had probably been at least a foredeck fitted. In addition, there was an increase in the freeboard aft, which would commonly be associated with a poop deck. Close inspection of this vessel in future may reveal evidence of beams that have since disappeared. The forward-most beam, only 930 mm long, was the only through-beam. Lodging knees were fitted to the beams (Figure 10).

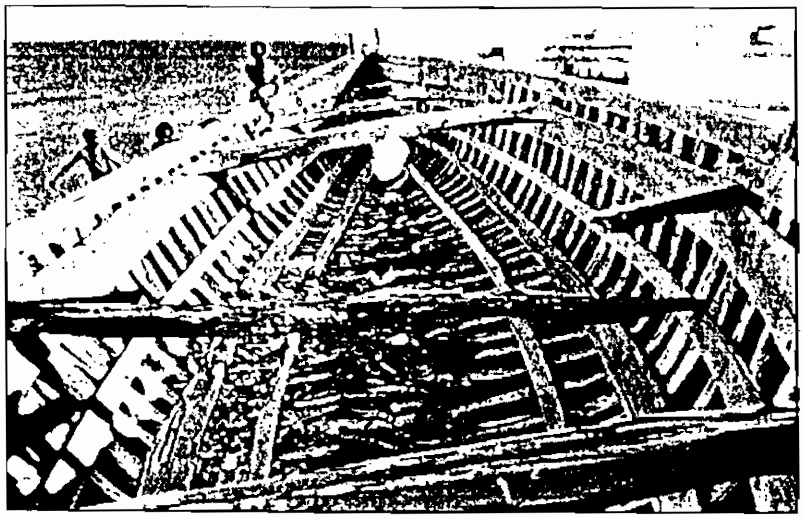


Figure 9. Bilge stringers on cargo badan *at Mahkleef.*

There was a series of holes of about 8 mm diameter through each caprail, from the lower outboard

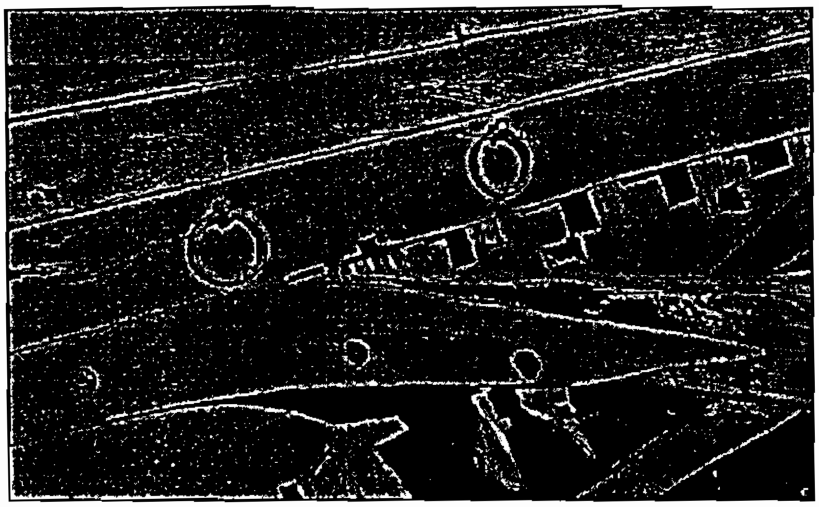


Figure 10. Lodging knee on the Mahkleef badan. *Note the notches for beams in the beam shelf.*

edge, angled obliquely upward to pierce the top surface of the caprail. Spaced 120-140 mm apart, the holes began about 2000 mm from the stem and ended at the vertical post near the 'poop'. Perhaps they were for lashing a cover over cargo.

A pair of bollards, one each side, extended through the caprail near the bow. In the same region, two bolts with loose rings were nailed to the inwale. It is presumed these rings were belaying points for rigging, much like those seen on the Kumzari *battil* described below.

Another bollard, longer and with carved decoration, was at the point where freeboard increased on both port and starboard sides. A carved geometric decoration was noted on the outside planking in way of the 'poop'.

The aft hood ends of the planking were fitted into a deep V-shaped rabbet, much like other *badan* that were seen during the research. This type of construction would allow the aft ends of plank to be firmly held in position during initial planking up, without using fastenings that might split the plank. It is thought that the sternpost, nailed in just forward of the rabbeted piece would have been fitted at the same time as the floors and half-frames, after planking was complete, or nearly so. Though a similar rabbeted member was now missing from the bow, it appeared that the same arrangement was employed there.

At Ashkharah south of Ra's Al Hadd, the four cargo *badan* were clearly abandoned, one being in a state of collapse and the others deteriorating. Their primary use seemed to be as a platform for drying fish. They provided, however, opportunities for recording construction features and joinery. At the time the team visited Al Ashkharah there was a strong sea-breeze blowing that prevented the use of plumb bobs thus limiting the range of methods available for recording the lines. However, an attempt was made to record the shape of one vessel (AS1) by photogrammetry. Even this method proved difficult, but some results were possible (Figure 11). This was a poorly controlled experiment and gives only a general idea of the hull shape, with no accurate scale. It would be interesting to have the opportunity to compare these results with data gathered by more rigorous and exacting methodologies. However, one can make some general observations on hull shape. In common with the smaller fishing *badan* of the Batinah coast, this vessel has sharp deadrise. The turn of the bilge is harder than in the small *badan*, but the knuckle (really a subtle chine) where the planking of the lower body meets the top sides is very pronounced, as in most fishing *badan*. There is a curious bulge to the section lines in the region of the garboards. Whether this form is original or due to hull distortion (the more likely cause) is not known. These vessels have been on the beach for many years and one would expect to see much distortion.

AS2, a cargo *badan*

Another of the cargo *badan* (AS2) was examined for constructional features (Figure 12). This vessel was heavily built and clearly a sailing cargo *badan*. Unlike the fishing *badan* of the Batinah, these cargo *badan* had a true keel and not a keel plank with twin skegs. There were forty-eight

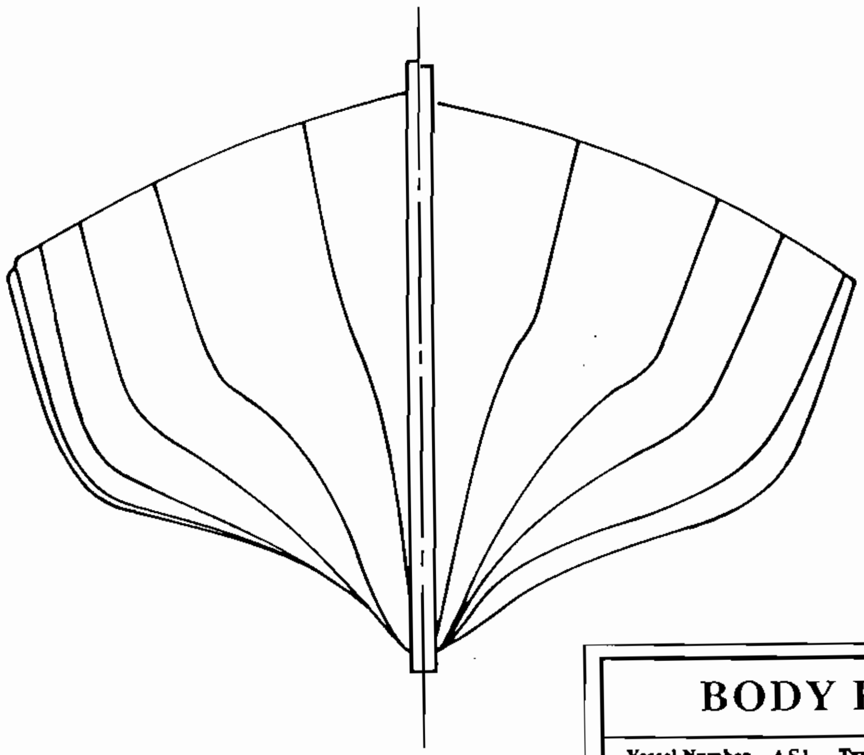


Figure 11. Section lines of cargo* badan *AS1, taken by photogrammetry.

frame stations following the pattern of floors with futtocks scarfed on to them alternating with fillers or half-frames. The scarf joints between floors and futtocks were simple, short and crudely fashioned.

A mast step about two metres long was checked over the floors and frames and braced on either side by longitudinal timbers fastened alongside the step to the floors and heels of the frames (Figure 13). Two rectangular mortises about 70 mm deep were present in the mast step, the aft one for the mast and the forward one for the short spar to which the mast is traditionally lashed.

The *obaidar*, or lower halyard block, was still fitted (unlike those on the *battil* seen at Kumzar, where they were missing). The obaidar was fitted through the deck, its forward face checked into the aft side of a heavy deck beam (Figure 14). Below deck a brace was tenoned into the aft heel of the *obaidar* with its other end tenoned into the next deck beam aft. On either side of the obaidar a belaying rack was fastened to the deck and deck beam. This showed extensive wear from rope abrasion.

A beam shelf supported deck beams, but no other stringers were present. In contrast, the hulk of a cargo *badan* examined at Mahkleef had three sets of stringers in addition to the beam shelves.

A typical *badan*-style beak head was fitted at the bow, with upper cheek knees to brace it. A set of four pairs of cheek knees braced the stern fin. The stern fin was not pointed as in a Batinah *badan*, but truncated. No rudders were fitted and unfortunately the method of securing them, had they been present, was not recorded. One must assume that they would have been steered with a

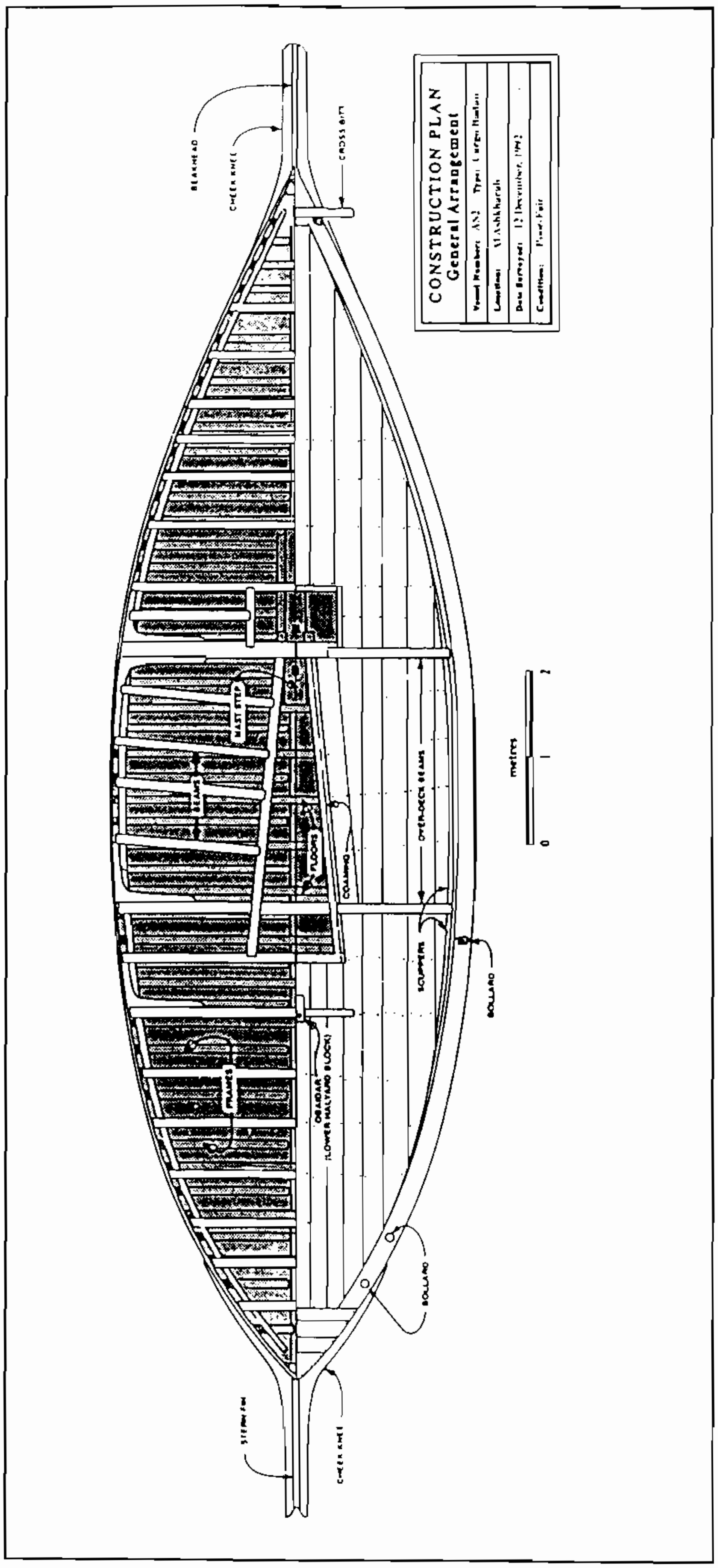


Figure 12. Construction and General Arrangement Plans of cargo badan *AS2.*

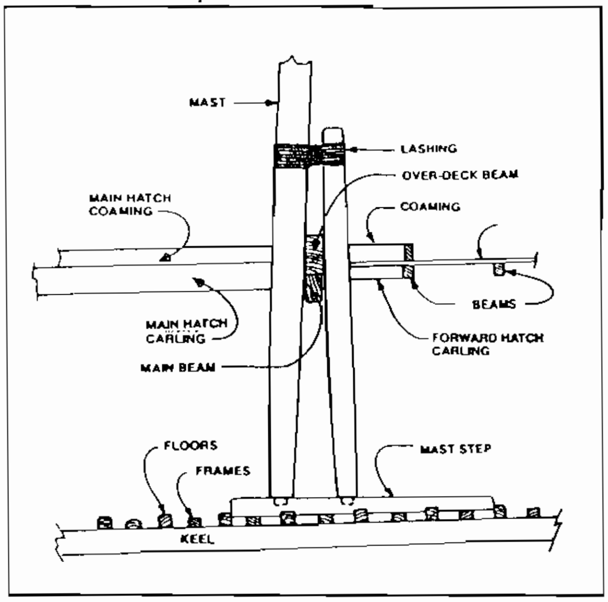


Figure 13. Elevation in way of mast, AS2.

system similar to the *badan* of the Batinah Coast and that one of the aft bollards on each side at the caprails would have used for the toggles of the steering ropes.

Near the bow, wooden fairleads were spaced at about two-metre intervals along the outside of the gunwale. These had probably been used to secure rigging. In the aft portions of the vessel several bollards protruded through the caprail, and a cross bitt for handling the mainsail tack and grounding tackle was fitted near the bow.

Though the masts were missing from all four *'uwaisiyyah* at Al Ashkharah, the structure for supporting the mast was extant in three of the vessels. The deck structure, particularly in way of the mast, was heavily built. The usual long trapezoidal-shaped hatch typical of Gulf Arab sailing craft was provided amidships (Figure 15). At its forward end a complex system of joinery supported and distributed the thrust of the mast against the heavy deck beam, with another beam fitted above deck for extra strength. Beams in way of the hatches and obaidar were braced with lodging knees. The over-deck beams near the aft end of the main hatch were checked into the inwale. On either side of this over-deck beam rectangular-section scuppers were fitted through the inwale and outer planking (Figure 16). To protect the end-grain of inwale and planking in way of the scuppers, each side of the scuppers was lined with a piece of timber. The inwale in way of the hatch was of a heavier scantling than the general inwale. A small rectangular hatch was located just forward of the main hatch, through which would have protruded the short spar to which the mast itself would have been lashed.

BAGGARAH

The town of Shinas, near the border with the United Arab Emirates, was home to the usual collection of *houri* and *shashah*; but here also were found two *baggarah*. The first (SH1) was found nearly buried in the beach sand. The visible portions were recorded, and tentative digging revealed some additional features for documentation. The second (SH2) is on display on the seaward side of the fort.

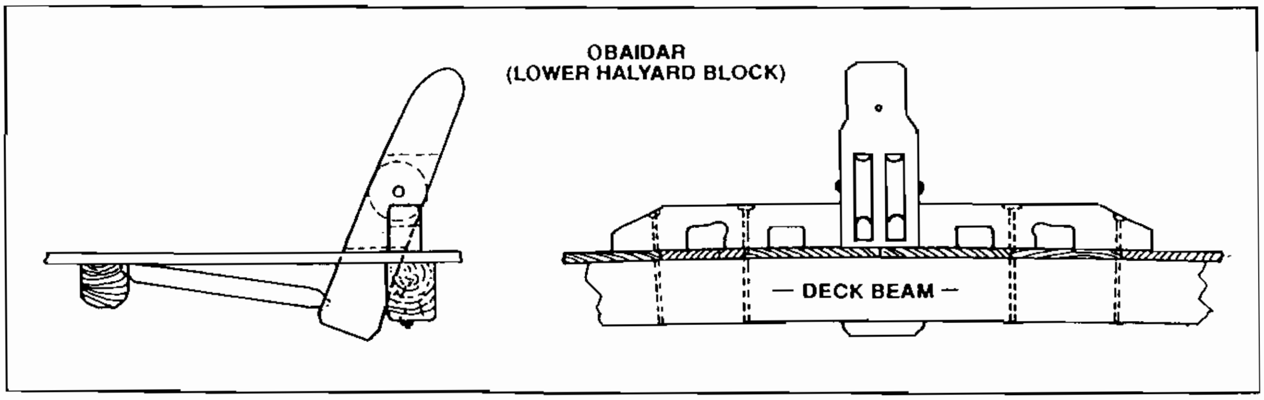


Figure 14. Starboard and fore elevations of obaidar *of cargo* badan *AS2.*

Shinas boat count:
Houri: 16
Shashah: 15
Baggarah: 2

SH1: a *baggarah*
Location: beach of Shinas buried in the sand up to the caprail; exact location of the stem was recorded in UTM coordinates by engineers from Nortech who were surveying the area.

Position: WGS84, Zone 40, E 446684.80, N 2733378.35
Length overall: 16265
Maximum beam: 1970
Accuracy of measurement: dimensions ± 20
General description:
The vessel probably qualifies as a *baggarah* but assessment can only be preliminary since the hull is buried in sand up to the caprail. Below the exposed part preservation of hull planking in the sand seems to be fair, the wood retains its brown colour (it has not turned grey) and is not significantly desiccated. The condition of the bottom of the boat and of the framing in the sand-filled hold remains unknown. Judging from the fairly preserved planking the lower parts of the hull must have survived equally well if it did not suffer any pre-burial damage.

Very elongated in shape the hull has a long midship section or section of maximum beam where the gunwales are parallel. The sides of the slender body run into pointed ends, with long overhangs.

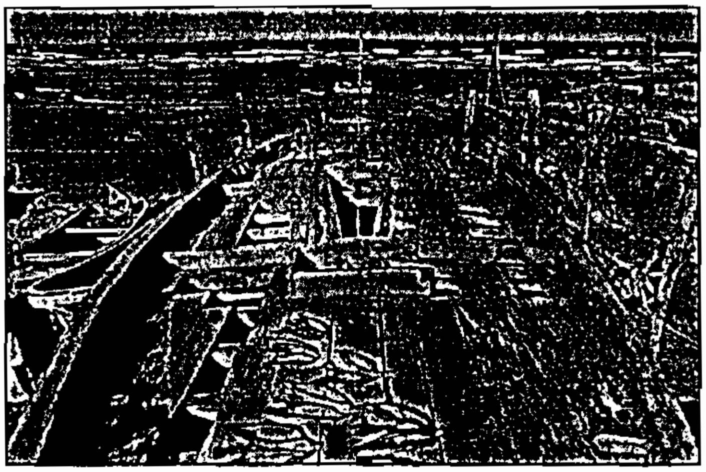


Figure 15. Deck of cargo badan *AS2, looking aft.*

The high tail fin, similar to that of a *badan* but with a square rather than a pointed tip, gives away the otherwise well hidden hull. Like a *badan*, the vessel is double-ended, but its straight stem exhibits a pronounced forward rake, similar to the raking bow of a *battil* or a *mashua*. The sternpost is also raked, and in that differs from the vertical sternpost of the *badan*, that joins the keel at a right angle. It is fastened to the keel slightly forward of the keel's after end. The planks of the tail fin are held in place by nailed cheek knees, upper and lower. Both pairs are splines that run along the stem planking, the sternpost and the fin planks. The upper cheek knees run along the underside of the caprails and project slightly beyond the after edge of the tail fin to create a small notch, which presumably secures the rudder in place while it is still possible to change its angle.

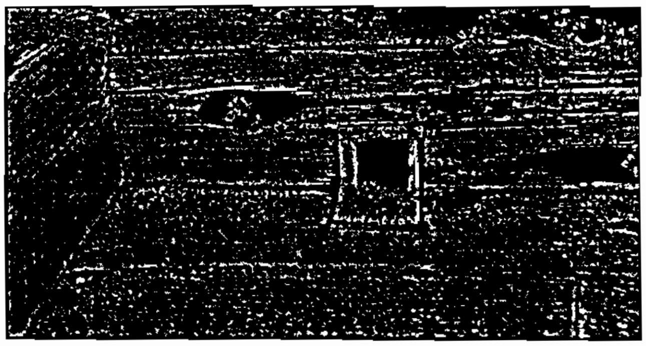


Figure 16. Scupper on cargo badan *AS2.*

The vessel has an open hold with partial decks at bow and stern. The afterdeck main beam is braced by a pair of lodging knees, one on either side. The starboard knee is preserved intact while the port knee has its fore-and-aft arm broken at its forward end. At the after end of the cambered afterdeck a pair of stanchions with carved finials are stepped onto the caprail. The main beam has a capping, cambered at its upper side. Inwales run along the sides of the deck. On each side the inwale consists of two main pieces, one over the other, filling the space between the deck and the caprail.

The foredeck is also strongly cambered, turtle deck fashion, at its forward end and has a capping with an arched upper edge on the main beam. A plain cross bitt is located far forward on the bow.

Forward of amidships (but still at the widest part of the vessel) two beams are identified as partners although there is no notch for the mast. Two pairs of notches, two on the forward edge of the after partner and two closer together on the after edge of the forward partner, are designed to take the ends of carlings of which only the port one is still nailed in place. A lodging knee with a long fore-and-aft arm is nailed to the after face of the forward partner. The short arm is nailed to the partner with two or three nails. The long arm extends aft, running over the after partner. On the port side the caprail stops short of the end of the knee revealing how the latter is notched over the frames. On the starboard side the very tip of the knee is broken off. In addition the forward partner is braced by a single lodging knee attached to its forward edge on the starboard side. A stringer runs along each side of the vessel below the knees.

Figure 17. Hooked scarf in keel of* baggarah *SH2, at Shinas.

Caprails are present near bow and stern but entire sections are missing amidships on both sides. They are pierced with square openings for thole pins and rectangular openings for the notched ends of frames. Their outboard edges are flush with the exterior planking surface.

Samples taken include:
Sample No. 28, a nail
Sample No. 29, three dowels

SH2: a *baggarah*
Location: set up as an exhibit beside the seaward wall of the fort.
General description:
The vessel constitutes a display beside the fort of Shinas. The timber has obviously been oiled and the hull reinforced by a framework of beams and rafters inserted in the hold. Remarkably the hold is entirely free from litter, an indication that the vessel is regularly maintained.

The lines of the hull are slender and elegant, with long overhangs. Narrow in beam and long, the vessel has a distinctive profile, to a large extent the result of the angular line of the keel. Some way aft of amidships the keel exhibits an obtuse angle, its after part rising upwards in a straight line to meet the sternpost. The design fits with the description of the keel configuration shared by *battil* and *baggarah* according to *Oman, A Seafaring Nation*: 'This [the keel] was in two almost equal parts, the shorter stern portion sloping gently upwards to the stern-post' (*Oman, A Seafaring Nation: 142*). At Shinas we observed that the two parts of the keel are fastened together with a hooked scarf (Figure 17). There are in addition hooked scarfs connecting the parts of the keel and the stem to the keel.

The stem is long, straight and significantly raked (Figure 18). The sternpost is shorter and exhibits a less pronounced rake. Attached abaft the sternpost is a planked stern fin with a square-tip high above deck level. The fin is held between two pairs of cheek knees, upper and lower. These are independent splines (as opposed to continuations of other timbers such as wales or caprails). The upper cheek knees run below the caprails and are longer than the lower cheek knees. Both sets project slightly beyond the fin to form two notches for securing the rudder.

At the bow is a cross bitt with carved ends. The foredeck slopes following the sheer. The foredeck main beam is braced by a pair of lodging

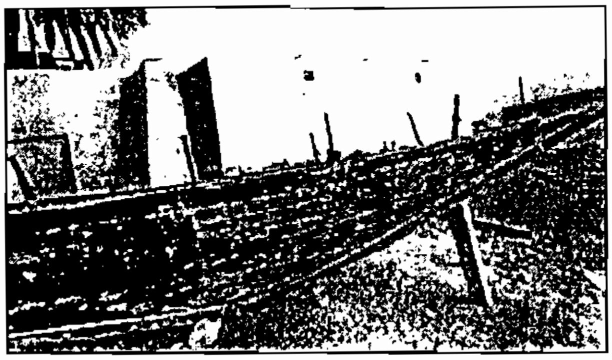


Figure 18. Bow of **baggarah** ***SH2, Shinas.***

knees, one on each side.

The afterdeck follows the sheer line sloping downwards at its forward part. At its after end a small cubby hole is planked at its forward face and the central plank is pierced with an ogee shaped opening. On either side a stanchion is stepped into the caprail and a crosspiece is mounted on their upper ends, the whole structure being similar to gallows. The tips of the stanchions are carved. The sides of the deck are lined by inwales, each comprising of two pieces that fill in the space between deck and caprail. The main deck beam is braced by a pair of lodging knees, one on each side. The athwartships arm is nailed to the forward face of the beam while the fore-and-aft arm runs along the side of the hull. The forward face of the deck beam is decorated with an elegant carving of adjacent triangles.

The framing is very dense, with fifty-six frame stations. Their arrangement in the hold follows the typical pattern of alternating floors and paired half-frames. Nailed to the frames a beam shelf runs along each side of the hull. Forward of amidships two beams are identified as mast partners. They are braced by a pair of knees each, attached to the forward face of the forward beam and to the after face of the after beam. The fore-and-aft arms of the after pair are notched onto the frames underneath the caprails. A pair of carlings runs fore-and-aft, at an angle converging towards each other at their forward end. They are nailed into notches cut in the beams.

The outboard edge of the caprails is flush with the exterior surface of the planking. The caprail has rectangular openings for the notched ends of frames and square openings for thole pins.

SHASHAH

Elements of the research team were fortunate to discover at Khawr Rasi the commencement of construction of a *shashah* (Figure 19). While some researchers worked on recording the *badan* at Khawr Malah, others spent several days recording on video and by notes, photographs and drawings the construction process of the *shashah*.

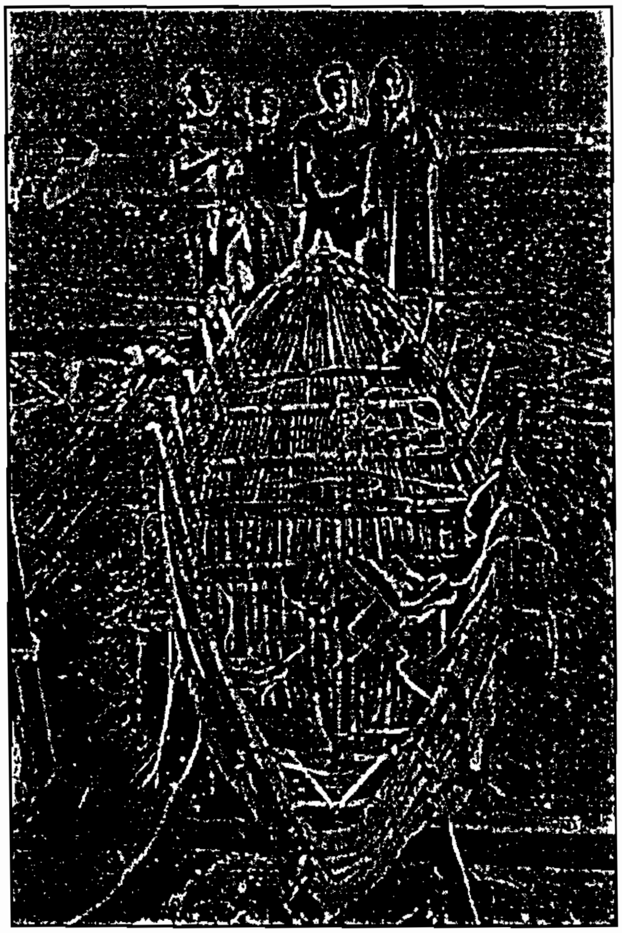


Figure 19. A **shashah** ***under construction.***

The attention of researchers was drawn to this process when they saw the *barasti* material for the construction of the *shashah* being unearthed a few metres from the beach. The *barasti* sticks, or rachis of the date palm leaves, are buried in the sand near water's edge for several days. Presumably, this would make them more pliable. It also may serve to 'pickle' them, as is done with some boat building timbers and cordage.

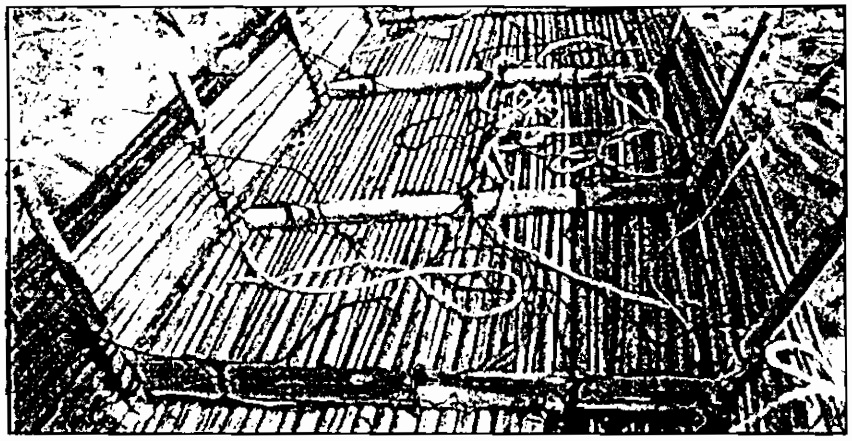


Figure 20. Detail of deck of the shashah *under construction.*

The *shashah* is a small fishing craft intended for one or, at times, two men. Traditionally they are rowed, but some had been modified to fit an outboard motor. By definition, the *shashah* is not a boat, but a raft. Structurally it comprises two layers with flotation sandwiched between. In the past this flotation would have been the porous and buoyant butt ends of date palm leaves but today the much more buoyancy styrofoam is generally used instead. Modern materials are used also to fasten the parts of the *shashah*, with the individual palm sticks being lashed to one another with polypropylene line. A small knife or bodkin is used to pierce the sticks and pass the lashing material through the palm stick. The bodkin is inserted in the palm stick parallel with its stem and twisted to open up the hole so that the lashing cord may be passed through.

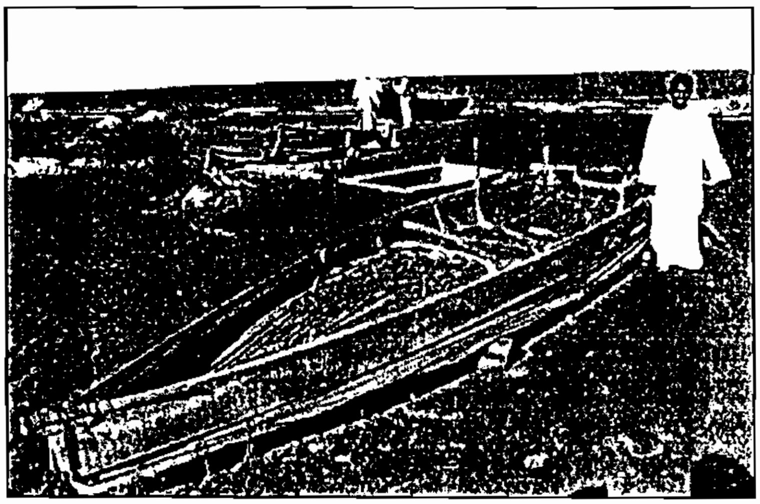


Figure 21. Hybrid shashah, *with timber washstrakes.*

This *shashah* was 5500 mm long with a beam of 1000 mm. The palm sticks, about 4000 mm long, are lashed to each other and to five thwarts which cross the 'deck' and ten stanchions (five each side fitted just aft of the thwarts). Some of these stanchions serve also as thole pins for the oars. There is a set of five 'floors' lashed to the inside of bottom layer of palm sticks. Each of these thwarts is lashed amidships to its corresponding thwart above (Figure 20).

The butt ends of the palms form bow and stem, with the outer, tapering ends of the sticks amidships. The bow and stern ends of the palm sticks are crossed near their ends and fastened together with a dowel driven vertically through them. This procedure was not noted on other *shashah* seen be the research team.

On the beach at Majis was an interesting hybrid—a *shashah* with planked washstrakes (Figure 21). This combination of materials was seen nowhere else during the research.

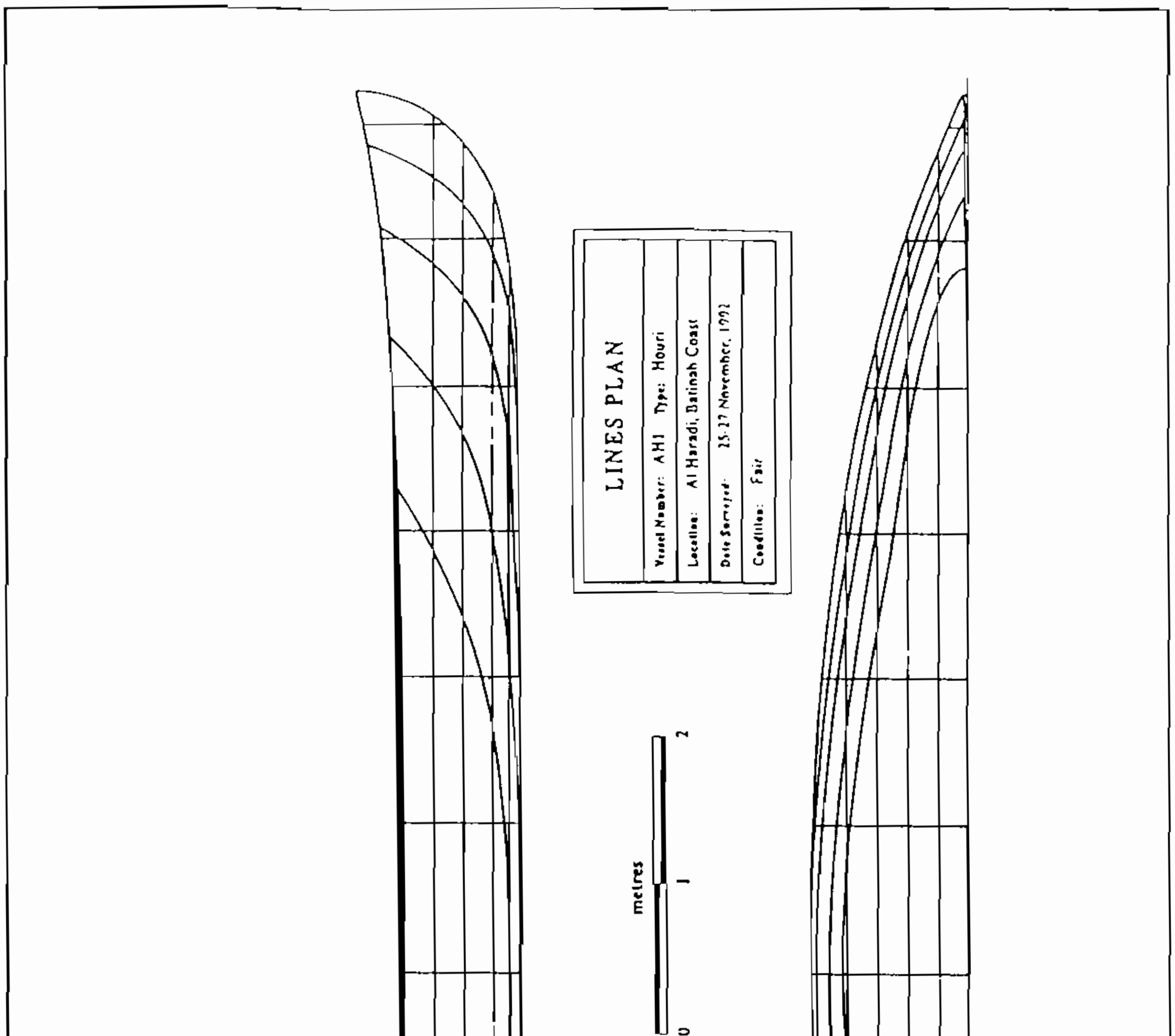


Figure 22. Lines Plan of houri *AH1, at Al Haradi.*

HOURI

Houri is a term applied very generally to almost any small boat. Strictly, a *houri* is probably defined as a dugout canoe, but several types of small vessel are called *houri*. These might be dugouts, dugouts extended with plank washstrakes, and completely planked small boats.

AH1: a *houri*
Location: in the fifth *barasti* on the Al Haradi beach from the right facing the sea
Overall length: 7960
Maximum beam: 1110
Accuracy of measurement: dimensions ± 5
scantlings ± 2
General description:
The vessel is a dugout *houri* with raised sides and an added counter or transom stern. According to the owner, the hull is ten years old. The timber was imported from the Malabar coast of India, presumably in a double-ended, dugout form (Figure 22). The washstrake, riders, frames and the counter stern were added in Oman. Supposedly the entire hull, including both the Indian dugout and the Omani additions, is made of mango wood (*lamba*). The wood is dry and deteriorating and shows no signs of maintenance. Like other examples at Al Haradi and elsewhere, the vessel is primarily used as a storage area for fishing nets; at the time of recording, however, the hold was empty and its bottom was covered with sand.

Two skegs, or longitudinal timbers are fastened side by side to the underside of the vessel. The fasteners are iron nails driven obliquely from the outside into triangular notches cut on the surface of the skegs.

One end of the vessel has a transom stem built on, presumably for fitting an outboard engine (Figure 23). The pointed stern retains its rising sheer line and the counter is fitted at gunwale level. A flat wing extends aft on each side forming the 'counter' with additional pieces for raised sides and a crosspiece at the aftermost edge just beyond the pointed stern. This arrangement was typical of motorised *houri* at Al Haradi and elsewhere on the Batinah Coast.

The washstrake is fastened with iron nails hammered from the outside into pre-made (chiselled) triangular notches. The spacing of the fasteners is irregular, averaging 200 to 250 millimetres.

***Figure 23. Plan view of transom mount for an outboard motor on a* houri.**

Below the washstrake additional planks are incorporated in the sides of the dugout as 'patches'. The patches are fastened with round-headed rivets driven from the outside through a square rove on the inboard surface of the hull. The planking seam fastened by the rivets is of the lap joint type that is common in Southern India and Sri Lanka

In the interior of the hull a number of roughly shaped timbers are fastened across the bottom or up the sides simulating floors and half-frames. Their arrangement and spacing do not follow a strict pattern and they vary in dimensions. They are fastened with round-headed nails (20 mm in head diameter) driven from the outside and double clenched on the inboard surface of the framing timbers.

The inboard surface of the dugout has six low-relief strips sculpted proud across the bottom and extending up the sides. At each end the surface is carved to a step in slightly higher relief. Forward of the fifth strip from the bow there is an additional carved feature of rectangular shape. It bears two slight, roughly circular depressions and its forward edge is shallower and irregular, perhaps worn. The purpose of this element is unclear. It may be an unfinished mast step, which the maker carved leaving its final form to the user of the vessel. The mast step would be placed in the largest sectional area of the vessel, far forward in the sailing dugout. Its position so far aft may indicate that the transom was added to the end that had been the bow in the originally double-ended craft. The shift may be related to the need to locate the largest sectional area of the vessel close to the centre of effort.

At the bow the bottom is pierced by a drain hole, for which no plug exists in the vessel. Further forward and at gunwale level above the edge of the carved 'step', a crossbeam is fastened to the sides of the bow with two nails per side. A pair of risers, one on each side, runs from this point below the cross beam to the a point right above the edge of the carved step at the stern. They pass over the framing timbers but are not notched to fit on them. They are fastened with slightly smaller, round-headed iron nails, driven from the inside and double-clenched on the outside surface of the hull. Some of the nails in the stringers are obviously remnants of earlier use indicating that the stringers may be re-used timbers.

Other characteristics of *houri* AHI include a round hawse hole pierced through the upper solid part of the bow and traces of light blue paint on the port side. According to a demonstration by a local fisherman the hole held the anchor warp when the boat was in use.

AH2: a *houri*
<u>Location:</u> in the sixth *barasti* on the Al Haradi beach from the right facing the sea
<u>Overall length</u>: 8770
<u>Maximum beam</u>: 1030
<u>Depth of hold</u>: 890 (bow), 460 (amidships), 790 (stern)
<u>Accuracy of measurement</u>: dimensions ± 5
<u>Samples</u>: #1, caulking of cotton and shark oil.
<u>Diagnostic characteristics:</u>
The vessel is double-ended. A wing stem crowns the bow while a false stem reinforces the foremost part of the hull. The vessel has added frames, stringers, washstrakes and the wing stem, but no wales. The washstrakes extend from the bow where it meets the wings of the wing stem to a point about 1840 mm forward of the stern. The stringers are checked over the frames, and at least one of the stringers has an extra notch (not fitting over a frame) which may indicate that this stringer is a re-used timber. The vessel has two 'anchor holes': a round hole at the upper part of the stern and a square hole at the foot of the bow. At the time of recording the hold of the vessel was filled with nets that did not allow us to determine the nature of the frames and of possible carved features on the inboard surface of the dugout.

AH3: a *houri*
<u>Location:</u> in the seventh *barasti* on the Al Haradi beach from the right facing the sea
<u>Length overall</u>: 5470
<u>Maximum beam</u>: 775
<u>Depth of hold</u>: 520 (max)
<u>Accuracy of measurement</u>: dimensions ± 5
scantlings ± 2
<u>Samples:</u> #4, frame timber.
<u>Scantling list</u> (all measurements in mm)
Stringers (aft star) width: 33
thickness: 20-25
(aft port) width: 40 thickness: 21
(fore star)width: 17 thickness: 19
(fore port)width: 27 thickness: 26
Wales sided: 20 moulded: 25
Stealer strakes length: 3020 (starboard),
3030 (port)
maximum width: 85
Limber holes sided:30 at the bottom,
20 at the top,
moulded: 20

General description
Houri AH3 is the smallest of its type at Al Haradi. It is double-ended with a wing stem fitted on the bow and a false stem fastened to the forward end of the dugout (Figure 24). Probably its most distinctive feature is a pair of inserted drop strakes on either side of the bottom of the hull. These narrow strakes must represent repairs: the wood grain is different from that of the

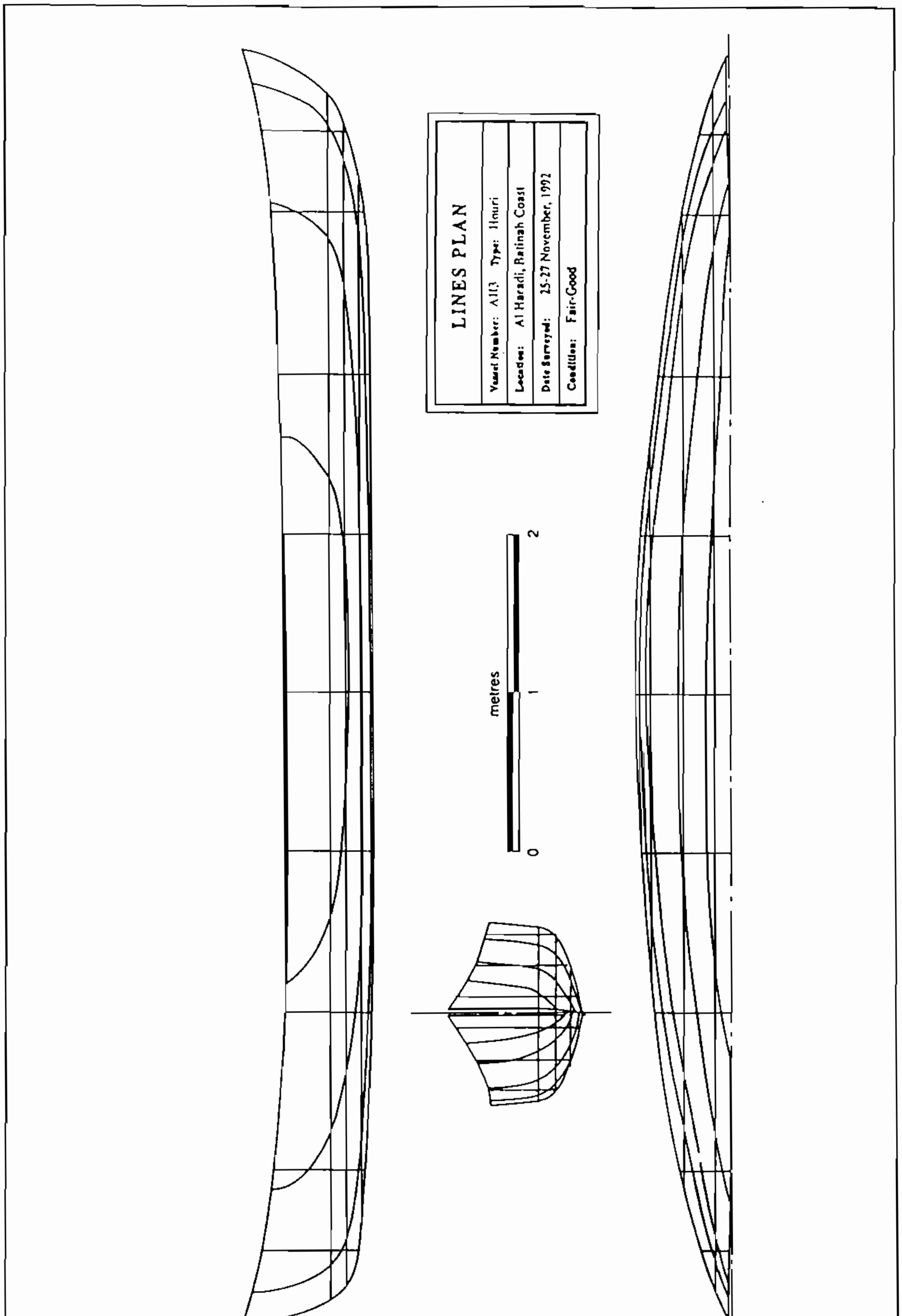


Figure 24. Lines Plan of houri *AH3*

rest of the hull and the wood surface bears obvious band saw marks (Figure 25). Noteworthy is that the strakes are fastened to the dugout bottom with wooden dowels. The dowels are driven in obliquely from the inside.

The inboard surface of the hull is carved with strips or floors which extend up the sides but are interrupted by the stealer strakes.

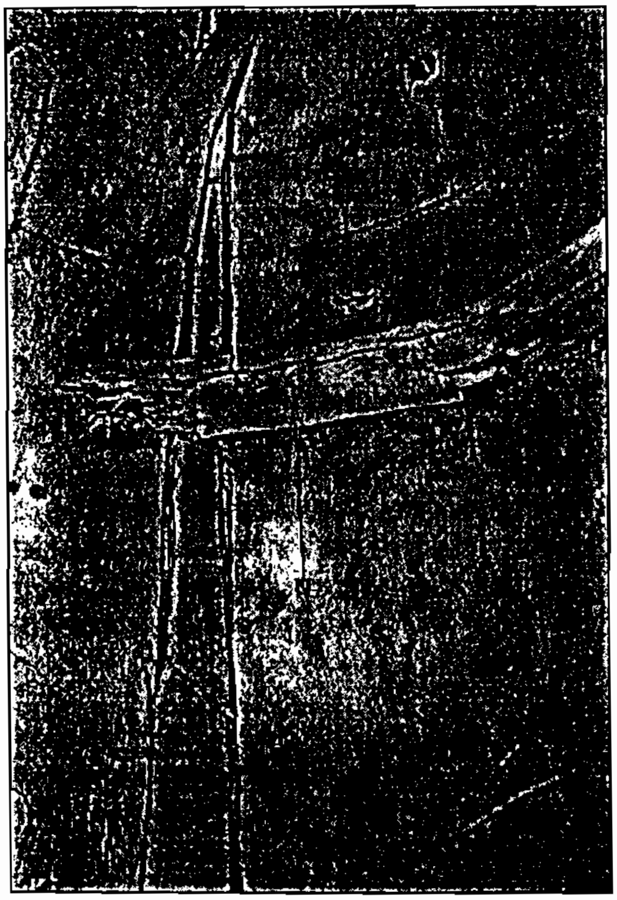


Figure 25. Filler strake fitted in dugout hull of houri *AH3. Note partial frame.*

The framing comprises five frame stations; the three foremost are floors with a single limber hole in their centre. Other additional pieces include stringers and crosspieces. The stringers are not continuous. There are four pieces altogether, one at each end on each side. They may be reused timbers for they bear dowels with no apparent function. The crosspieces, one at the bow and one at the stern, are fastened to the sides of the hull just below the washstrakes. Also two wedge-shaped blocks are nailed onto the sides of the wing stem.

A square hawse hole is located fairly high up the bow.

AH4: a *houri*
Location: along the seaward wall of a storeroom of a house situated behind the 12th and 13th *barasti*.
Overall length: 8880
Maximum beam: 1140
Accuracy of measurement: dimensions ± 5
Diagnostic characteristics
The vessel has a transom stern. The inboard surface of the dugout exhibits strips sculpted athwartships in low relief and stepped ends. The added frames comprise floors and paired half-frames or side frames, fastened with double clenched nails. Most floors are roughly squared. Side frames are mostly natural, grown timbers. At the stern, frames are checked over the angle formed between the top edge of the hull's side and the washstrake. Noteworthy are wooden dowels along the upper sides of the hull; the ends of these dowels are flush with the hull surface. On the starboard side a lower rowlock fitting or cleat is placed between two frames and fastened to the hull and the stringer with two dowels, fore and aft of the opening for the thole pin. The forward dowel is dislocated but the after dowel is in place. Three altogether, these fittings are staggered longitudinally, two on the starboard side and one on the port side; except for the one described above the other two are firmly fastened. Four beams span the hold athwartships (midship beam, 60 mm sided, 40 mm moulded). The stringers extend to the edge of the stepped ends. They are of uneven dimensions along their length (average 40 mm sided, 50 mm moulded). The port stringer comprises two pieces, one notched at its end to fit onto the other. The vessel has wales on both sides but of the port wale only a small piece survives.

AH5: a *houri*
Location: along wall of storeroom of house standing behind the 12th and 13th *barasti*

(same as AH4)
Overall length: 9410
Maximum beam: 1115
Depth of hold:
Accuracy of measurement: dimensions ± 5
Diagnostic characteristics
This vessel is double-ended. At the bow a two-piece wing stem is surmounted by a single piece one. Added pieces include wales, risers and three thwarts nailed to the stringer with two nails on each end. On the starboard side a rowlock fitting preserves both upper and lower cleat; the upper cleat is lashed to the gunwale. The hull has a hawse hole through the upper solid part of each end. Traces of light blue paint survive on the inboard surface of the hull and the bow is marked on the outside with the neatly carved letters SH.

AH6: a *houri*
Location: next to a *barasti* in front of the grocery shop
Overall length: 8370
Maximum beam: 1090
Depth of hold:
Accuracy of measurement: dimensions ± 5
Samples:
Diagnostic characteristics
This vessel is double-ended, with a very solid, true wing stem. The inboard surface of the dug-out is carved with six strips or floors in unusually high relief (moulded depth: 30). On the starboard side forward is a remnant of the washstrake. Nails are still in place where it has been ripped out. Stringers extend to the edge of the carved step at both ends. The starboard stringer is pierced by round holes of no apparent function indicating re-use. One joint between dugout body and a 'patch' is split open, providing a clear illustration of how the patches are attached to the hull with lap joints.

AH7: a *houri*
Location: next to AH6
Overall length: 7570
Maximum beam: 1100
Depth of hold:
Accuracy of measurement: dimensions ± 5
Samples:
Diagnostic characteristics
The inboard surface of the dugout is carved athwartships with six strips in low relief. Only one end is stepped. Amidships a dovetail fastener is set athwartships on a sculpted strip and is fastened with a wooden dowel on each wing. A wale runs along each side for most of the hull's length. Both ends have hawse holes.

AH8: a *houri*
Location: next to AH7
Overall length: 8850
Maximum beam: 1165
Depth of hold:
Accuracy of measurement: dimensions ± 5
Samples:
Diagnostic characteristics
The vessel is double-ended and has a single-piece wing stem and a false stem at one end. The inboard surface of the dugout is carved with six floors and both ends are stepped. Both sides feature a stringer (extending from the edge of one end step to the other) and a wale. Three rowlock fittings are staggered longitudinally, two starboard and one port. Traces of yellow paint survive on the port side.

AH9: a *houri*
Location: some *barasti* down from AH8 near the mosque.
Overall length: 8080
Maximum beam: 1230
Depth of hold:
Accuracy of measurement: dimensions ± 5
Samples:
Diagnostic characteristics
The vessel is double-ended and features wing stems at both ends. One wing stem is fastened onto a second piece with a nail driven through the bottom of a notch which is cut at the centre of the upper timber. A false stem is attached on the outboard surface of the same end. The inboard surface of the dugout is carved with six strips and both ends are stepped. The stringers extend to the edges of the end steps on both sides and wales. One, made of two lap-joined pieces, runs the entire length of the vessel. Four beams, two of which are wide benches, span the hold

athwartships, and a crosspiece is nailed onto the washstrake at one end of the hull. Hawse holes are pierced at both ends.

AH10: a *houri*
Location: in *barasti* near the mosque (next over from AH9)
Overall length: 7780
Maximum beam: 1160
Depth of hold:
Accuracy of measurement: dimensions ± 5
Samples: #5, wood from the bow
Diagnostic characteristics
The vessel differs substantially from the typical *houris* in many of its features. It has a diminutive counter stern, a true post at the bow with a club-shaped tip, and its sides are to a large extent planked. The framing is very dense and six athwartship strips are carved on the bottom in particularly low relief. The wales and the washstrakes of either side meet forward of the bow. The shape of the vessel exhibits an unusually hard bilge. Several repairs and breaks as well as the condition of the timber indicate the old age of the vessel (at least 20 years according to a young man from the village who claims that the boat is older than himself).

AH11: a *houri*
Location: well hidden by nets, against the back wall of *barasti* near the mosque
Overall length: 8130
Maximum beam: 1020
Depth of hold:
Accuracy of measurement: dimensions ± 5
Samples:
Diagnostic characteristics
Houri AH 11 is double-ended, with a very heavy wing stem, and a false stem. The washstrakes run directly into this solid stem piece and are nailed to the sides of the hull with nails driven obliquely through the usual triangular notches, some of which are cut along the inboard face of the washstrakes. The vessel has five thwarts and a pair of very solid stringers fastened directly to the sides of the hull. Both ends are pierced by a hawse hole. At the time of recording the hull was filled with nets and grapnel anchors.

AH12: a *houri*
Location: between *barasti* close to AH 11
Overall length: 9330
Maximum beam: 1250
Depth of hold:
Accuracy of measurement: dimensions ± 5
Samples:
Diagnostic characteristics
The vessel has a counter stern and a double wing stem with a square hawse hole through the bow below it. The inboard surface of the dugout is carved with six strips in low relief and both ends are stepped. Added pieces include three thwarts, two crosspieces (at bow and stern) and wales that run the entire length of the vessel on both sides. Three rowlock fittings, two starboard and one port, are staggered longitudinally. The exterior surface preserves traces of light blue paint.

AH13: a *houri*
Location: in *barasti* directly in front of the mosque
Overall length: 8160
Maximum beam: 1130
Accuracy of measurement: dimensions ± 5
Samples: #6, luting from damaged stem
Diagnostic characteristics
The stern of the vessel is ripped out, the damage probably caused by the weight of an outboard motor mounted on a progressively deteriorating counter stern. The forward ends of the counter are still in place on either side. Also part of a lap joint is exposed at the break. Two beams amidships are braced in place by lodging knees set in pairs opposite one another. A third beam is located at the bow. Of the wales only a small piece survives at the starboard side of the bow. The vessel does not have skegs. At the time of recording the hold was filled with nets.

AH14: a *houri*
Location: last *barasti* of the continuous row in front of the village.
Overall length: 7930
Maximum beam: 1170
Depth of hold: not measured
Accuracy of measurement: dimensions ± 5
Samples: None

Diagnostic characteristics

The vessel has a counter stern. Added elements include thwarts, wales and fore-and-aft timbers along the sides of the hull which support a *barasti* deck. The single hawse hole is located in the stern; contrary to what we were told by other fishermen about similar holes located in the bow, the owner of this vessel claimed that the hole had no specific purpose. Its position, however, could be an indication that the end originally intended to be the bow was turned into a stern with the addition of the counter.

AL BASIT

Four *houri* in excellent condition were noted here. They appeared to be ready for sea.

AB1: a *houri*

This vessel is double-ended. It features a small, carved mast step and a mast partner with a semi-circular mast notch at its after edge. It also has four thwarts and 'reed' decking. Apparently the vessel is oiled frequently and maintained in good condition.

AB2: a *houri*

This vessel is double-ended and smaller than the others. It features four thwarts, two crosspieces at the ends and reed decking. In excellent condition.

AB3: a *houri*

This vessel is longer than the others and counter-sterned. Like the others of the group the surface is smeared with oil and the vessel looks ready to go to sea. In excellent condition.

AB4: a *houri*

This vessel has a counter stern but is also provided to take mast and sail. Its mast partner is a wide thwart with a round opening at its centre. The mast step consists of a socket carved out on the bottom of the boat. The deck comprises continuous thwarts as well as reed matting. The vessel is in excellent condition but also serves as a storage area holding nets under its deck.

AL MARAQ

Al Maraq: a coastal village next to Al Basit.

Al Maraq boat count: three wooden *houri* and eight fibreglass *houri*. Hanging from the roof of a *barasti* in front of a Baluchi grocery, is a carpenter's basket in the shape of a coracle, its framing consisting of an oval plastic ring serving as a sheer clamp, and two thwarts.

MQ1: a *houri*

This vessel is old and apparently not in use.

MQ2: a *houri* (sample No. 7 of wood from the stern of the vessel)

Located at the western edge of the village with the fibreglass *houri*, this vessel is unusual in being planked and having a true stem and a counter stern. The stem ends in a club-like tip similar to that of AH10. Four rowlock fittings are staggered along the length of the vessel, two on the port side and two on the starboard side.

MQ3: a *houri*

Located with M3 and the fibreglass *houri* at the western edge of the village just before the wadi, this vessel has a counter stern. Considerably aft in the bottom of the hull is a flat carved element in the shape of an ogee arch, possibly an unfinished mast step (Figure 26). If that is the case, the position of this 'blank' mast step so far aft indicates that the counter has been added to the end of the vessel originally designed to be the bow. At least two rowlock fittings are still in place (it was not possible to determine whether any more exist because the hold had a rigid cover).

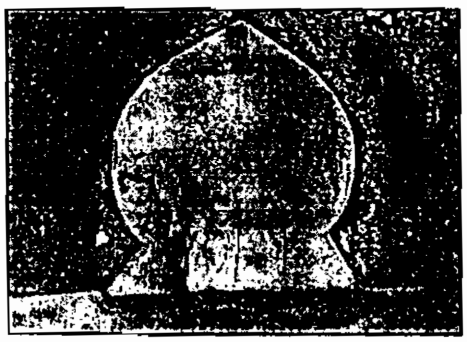


***Figure 26. Ogee-shaped 'mast step' in a* houri.**

Al Maraq fibreglass *houri*
The eight fibreglass *houri* are of standardised shape and construction. They are counter-sterned and feature built-in mast steps and mast partners amidships as well as staggered rowlock fittings, two on each side. Mounted on the bow a cross-piece with projecting ends may serve as anchor bitt.

BARKA
Barka: town north-west of Muscat and Seeb, across the wadi from Al Maraq.

Barka boat count: eight *houri*

BA1: a *houri* (samples No. 8, sternpost timber; No. 9, frame timber)
This *houri* is double-ended. Its stem is identical with that of M2 and AH10. Like M2 the hull is planked. The framing is dense and comprises 17 paired half-frames. At their upper ends the frames are cut to fit on the stepped joint between the upper strake and the washstrake, with the exception of the four frames at the stern where the washstrake stops. The stringers are heavy stringers, as is a midship beam. Four rowlock fittings are nailed (not trunnelled) to the sides of the hull. The two fittings on the port side preserve both their upper and lower cleat, while on the starboard side only the lower cleats are in place.

BA2: a *houri* in a *barasti* in front of Barka fortress
BA3: a *houri* in the *barasti* next to BA2, filled with anchors
BA4-7: four small *houri* in open air near the water, in very good condition and possibly in use
BA8: a *houri* in a house

MA1: a planked *houri*
Location: on Majis beach, straight down to the waterfront from the mosque
Overall length: 7390
Maximum beam: 1800
General description:
The vessel has a curved stem with a carved club-shaped tip, typical of planked *houri*. The stern is cut into a roughly triangular transom. The ends of the top strake and the caprail project slightly aft.

Instead of a true keel, two skegs or grounding keels run parallel along the bottom.

The vessel has an open hold with two partial decks at bow and stern. Both decks are very small. The foredeck is carried on three beams. The underside of the afterdeck was inaccessible at the time of recording.

A mast step and a single mast beam are located forward of amidships. The socket for the heel of the mast is 55 mm in diameter.

The framing system comprises twenty-five frame stations, arranged in the typical pattern of alternating floors/futtocks and paired half-frames. Only one exception was detected in the visible part of the hold: at frame station No. 5 a pair of half-frames is doubled by a short floor fastened alongside to it.

There are no wales. The caprail extends all the way from stem to stern projecting slightly aft beyond the end of the vessel. It features square openings for the thole pins that are all in place, four on the port side and three on the starboard side, longitudinally staggered. There are no lower thole pin cleats.

A stringer runs along each side of the vessel and is notched to take the main deck beams.

MA2 : a planked *houri*
Location: beached near MA1, further back from the water
Length overall: 9170
Maximum beam: 2800
Accuracy of measurement: dimensions ± 5
General description:
The vessel has an open hold with partial decks at bow and stern. The foredeck is 1520 mm long on the centre-line, with a cubby hole at its forward end and a rectangular hatch at the centre of its after end. The main beam is heavy and has a batten nailed onto its after edge. A cross bitt with

undecorated ends is set far forward at the bow.

The interior of the vessel was filled with fishing gear that prevented any observations on the framing pattern. The frame under the after end of the foredeck is a heavy floor forward of which the bottom of the hull is pierced by a drain hole plugged with a long cylindrical piece of wood.

The outboard edge of the caprail is flush with the planking surface and a wale thicker than the caprail is nailed along the side with its upper surface flush with that of the caprail. The caprail has rectangular openings for the ends of frames and square openings for thole pins. The vessel has eight oars, for which only five thole pins are in place (two starboard and three port).

The sides of the foredeck are lined by a pair of inwales. These are composed of two parts on each side; a main inwale, that covers in width most of the space between the deck and the caprail, and an upper batten that is inserted along the top of the main inwale.

MA4: a planked *houri*
The vessel was being repaired and was recorded on video.

MA5: a planked *houri*
The vessel is 10500 mm in length. The gunwale projects beyond the bow. The deep transom goes down to the deadwood.

MA6: a planked *houri*
The vessel is 8000 mm in length. Its very small transom is composed of a solid, one-piece, V-shaped timber that extends halfway down to the keel. The outboard motor, a Yamaha Enduro 30, is shipped.

MA8: planked *houri*
Near the house of the owner of MA7 a vessel lies abandoned at the back of the beach near the houses. It is obviously a very old craft, some of its planking has disintegrated or has been ripped out but all the frames are still in place. Unlike most planked *houri* in the area it is double-ended. Its sides are scored with wooden dowels of different shapes and sizes driven both through-plank and obliquely into plank edges. The planking also bears open holes, many of which must have held dowels that have been dislocated since abandonment due to progressive desiccation of the wood. The process of dislocation was still continuing at the time of recording.

A number of samples were taken:
Sample No. 24: a nail
Sample No. 25: an assortment of dowels
Samples No. 26, 27: wood samples

AT1-H
Length overall: 7180
Maximum beam: 1000
General description:
Houri with washstrakes fitted. The inboard surface of the dugout has six low-relief strips sculpted proud across the bottom and extending up the sides, serving as stiffening frames or floors. The dugout has split on the bottom and been repaired. The washstrakes comprise four planks each side, though one is missing on the starboard side. Stanchions are fitted on which to hang the washstrakes. There is one small cross frame or thwart fitted in the fore part of the dugout. Risers are fitted about 300 mm below the gunwale, with some sections missing. There is a wing stem forward, and a similar but bi-partite structure aft.

AT2-H
Length overall: 8240
Maximum beam: 1170

BATTIL and *MASHUA*

With the assistance of the Royal Oman Navy and the Royal Oman Air Force, four of the research team were able to visit Kumzar in the far north of the Musandam peninsula. The researchers not in Musandam were able to accomplish important work in Sur and Al Ashkharah, as well as enjoy a tour of some wadis, villages, forts and historical sites in the interior of Oman. In order to ensure that a staff member would be present with the members of the team at all times, and that all staff members could visit the important sites at Kumzar, Commander Tilley and Mr Vosmer rotated through Kumzar, Tilley being there the initial four days and Vosmer the last three days.

Kumzar is a remote village set deep in the fiord called Khawr Kumzar. A number of *shu'i* sheltered in the deep fiord, venturing out each day for fishing, and returning at dusk. These were always afloat and therefore not recorded. However, at Kumzar were found some of the most remarkable vessels seen by the expedition. Along the shore in front of Kumzar proper were eleven vessels, three small ones (about 7 metres long) which are locally called *mashua*, and eight larger (about 10-11 metres), locally referred to as *battil*. *Oman A Seafaring Nation* refers to these vessels as *baggarah*, but differences were noted by the present researchers between the Musandam variety and those *baggarah* found on the north Batinah coast at Shinas. Contemporary literature states that the *battil* is extinct. While the Kumzari *battil* were not of the classic *battil* form, with large club-shaped stem profiles and a stern profile in the shape of a stylised dog's head, they were similar enough in form to be considered, if not the same species certainly the same family. The club-shaped stem profile was preserved in a diminutive form, as too generally was the 'dog's head' stern profile. One vessel did display the classic dog's head stern.

One of the *mashua* was under repair, with a new stern fin being fitted and some floors, framing and beams being renewed. It was possible to examine the original joinery of this vessel, as well as to observe the manner in which repairs were effected, and how these influenced the new joinery. In the first small bay to the west of Kumzar village, but within Khawr Kumzar, were seven vessels, comprising three *mashua* and four *battil*. Two of the *mashua* appeared to been in be use, one being afloat and another launched and rowed away during the time the team were there. All the vessels were in excellent condition. One of the *battil*, designated KO2, was carefully documented, with lines being taken, scantlings recorded and construction drawn and annotated. One of the *mashua*, designated KO1 was also recorded in detail, but without the lines being taken.

Khawr Koba, the first cove west of Kumzar in Khawr Kumzar (the spelling of this name is uncertain).
Khawr Koba beach boat count:
4 *battil* (on the beach)
3 *mashua* (one on the beach, two in use)

Brief note on the *mashua* (*mashuwah*)
The term *mashua* or *mashuwah* is mentioned in *Oman, A Seafaring Nation*. Interestingly the definition provided does not agree with our findings, due to the fluidity of regional definitions found in any culture. 'The term *mashuwah* is not heard frequently in Oman, where it is generally used to refer to small longboats, generally about 25 feet in length, of general utility and originating in the Gulf. They have transom sterns, straight, curved or vertical stems, and no deck. There is nothing except size, therefore, to distinguish them from a simplified *shu'i* or *jalibut*. They are normally propelled by oars but, like the *huri*, may be fitted with mast and sail. On the long run to East African ports the ship's carpenter on, say, a *baghlah* or *boum* from the Gulf, would often use his time to advantage by building a *mashuwah* for sale at the other end.'

The word *mashuwah* can have a very general reference, denoting any small, deckless, square-sterned boat, and has even been heard applied to an aluminium craft of that form' (Ministry of Information, 1979:153). At Kumzar, however, the fishermen use the term *mashua* to denote specifically the double-ended, fin-tailed oared wooden craft that they employ in coastal fishing. Some would also refer to the same vessel by the term *shahuf*, which however appears to be a generic appellation.

KO1: a *mashua*
Location: Khawr Koba beach, at the time of recording first boat from the edge of the beach closest to the village.

Length between perpendiculars: 6900 mm
Maximum beam: 1705 mm
Accuracy of measurement: dimensions ± 5
scantlings ± 2

General description:
The vessel stands on the beach with its bow facing seaward and is supported by shores lashed to thole pins on each side. It has an open hold with partial decks at bow and stern; forward of amidships a pair of bulkheads, set against the opposite edges of two partner beams, enclose a compartment. The *mashua* is in good condition, with its planking well oiled, its oars shipped, its thole pins in place (but without a rudder, the function of which, the owners told us, is now performed by oars) and its decoration preserved.

The keel is deep; at its forward end it curves upward and is scarfed to the raking stem. The sternpost is a straight, almost vertical timber, butted onto the upper face of the after end of the keel. A bolt, driven from the underside of the keel upwards, fastens the sternpost or an apron on its inboard side, to the keel; two nails or bolts are driven into the stem from the outside, presumably to fasten a similar apron to the stem. The keel itself consists of four pieces; the two scarfs for a noticeably small piece at roughly the midship section of the keel are nailed or bolted, the recessed heads of the fasteners showing on the outside. At both the bow and the stern the hood ends are laced together and to the posts; fastened abaft the sternpost is a planked 'tail fin' held together by a pair of cheek knees (upper and lower) on each side. The upper cheeks are extensions of the wale while the lower pair, running along the stern planking, the sternpost and the fin, are much lighter in section, and perhaps could be described as splines.

The tip of the stem is painted. A fibrous tassel is hanging off the tip. A pair of horns (called *kalib* or *kalb* [dog] in Arabic) is mounted at the bow aft of the stem; the horns are fashioned out of wood and painted, and bear traces of rope wear. While obviously decorative, this item appears to serve the same function as the less ornamental cross bit observed on the *baggarah* and *badan*. Abaft the horns a blue synthetic cord is looped around stem, planking and caprails for nine turns. Further aft (about 310 mm abaft the horns) a timber with a semi-circular upper edge and straight lower edge is nailed onto the caprails and marks the point at which those run separately aft on either side. The timber, which effectively acts as a breasthook, tying the forward sides of the vessel together, is decorated with brass dome-headed nails driven into its upper edge and bears incised characters on its after face.

The stern, particularly its tail fin, is also decorated. A number of belts or bands of various materials, some with stitched on cowrie shells, are stretched around the fin. Several athwartships planks roughly trapezoidal in shape, are fastened horizontally on the stern forward of the tail fin. This structure acts as a stern breasthook, tying the sides together aft. With the fastenings acting in sheer (rather than in tension as in traditional western breasthooks) a very effective method of construction is attained. The planks are studded with dome-headed brass nails set in a pattern of uncertain iconographic significance. (It may represent a *mashua* under sail). A tassel is hanging from the aftermost upper tip of the fin.

The framing pattern comprises floors with scarfed futtocks alternating with paired half-frames, or 'fillers'. There are twenty-four frame stations overall. Exceptionally, the two aftermost and three foremost frame stations comprise successive paired half-frames. Frames are fastened with iron, round-headed nails driven from the outside and double clenched on the inboard surface of the timbers. The stringer (or beam shelf) is nailed to the frames from the inside at every other frame. Further observations of the framing were not possible because the inboard surface of the hull was covered with mats of laced palm frond spines.

An actual mast step is missing from the vessel, yet the semi-circular notch at the after edge of the forward partner indicates the use of a mast. A removable mast step would be notched at its underside and checked over the floors; the floor at frame station No. 8 appears to have a slight depression or area of wear at the upper surface of its throat.

The caprail consists of three pieces on the port side and four pieces on the starboard side; the pieces are simply butted to or joined with diagonal or stepped scarfs. The two midship pieces of the starboard caprail appear to be later additions; they differ from the rest of the caprail in dimensions, wood colour and do not have openings for the upper ends of frames. In addition to such openings for the ends of frames (more closely spaced at bow and stern), the caprail is pierced by four roughly square openings for the thole pins, one pair (port and starboard) roughly amidships and slightly staggered and another pair aft of the afterdeck main deck beam. The outboard edge of the caprail is flush with the exterior planking surface; a wale is nailed onto this edge of the caprail and not to the planking.

The wale is of approximately the same thickness as the caprail and extends from the bow, where its ends are scarfed into the caprail, to the stern, where begin the upper cheek knees of the tail fin.

The foredeck is carried by four beams onto which the five deck planks are nailed. The main beam is rabbeted to take the deck planks; its ends are notched to fit over the stringer and extend to the sides of the hull to which they are fastened with a nail driven from the outside. The other beams fit into notches cut in the stringer (beam shelf) rather than being themselves notched underneath as is the main beam. The central plank, 1.20 m in length, is the widest and has a small filler plank at its after edge. The foredeck is a turtle deck designed to shed quickly any water that comes on board. The small cubby hole at the forward end of the deck is roofed by the converging caprails, while its bottom is formed by the flat top of the heavy timber apron set against the stem.

The forward stretcher is a fore-and-aft timber that runs at a slight angle to the centre-line and is socketed into the vertical after face of the foredeck's main beam and notched onto the forward edge of the forward partner beam. At both ends the upper surface of the timber bears a roughly incised 'X' mark.

The two partner beams, located forward of amidships, rest on the stringers. The caprails rest directly on the partners. Since the starboard stringer is fastened at lower level than the port stringer the partners have a stepped thicker starboard end. The forward partner has a semicircular cut-out notch roughly at the centre of its after edge; this 'mast notch' is flanked by two indentations on either side. The framing pattern in this area of the hull is standard, comprising alternating half-frames and floors; as already noted above, floor at frame station No. 8 shows traces of wear at its throat, that may indicate the presence of a removable mast step. A pair of cheek knees or thin fore-and-aft spans connect the two partners and are nailed to them on opposite ends.

The bulkheads, one forward of the forward partner and one aft of the after partner, form a compartment forward of amidships. The planks of the bulkheads are nailed to stanchions. The forward bulkhead consists of two planks and a small filler piece; its two stanchions are stepped on the half-frames and fastened into notches in the forward vertical face of the partner. A number of wooden pegs in the upper plank (with both ends flush with the plank surface) do not appear to serve any specific purpose and may indicate that the plank is a re-used timber. The small filler plank is fastened edge-to-edge to the upper plank with a nail driven obliquely from above. There is some space between the upper edge of the bulkhead and the lower surface of the partner.

The after bulkhead has three stanchions instead of two; these stanchions are also notched onto the partner and stepped on a framing timber, in this case a floor. The upper plank partly overlaps the after face of the after partner and its upper edge is bevelled flush with the partner upper surface.

The after stretcher runs from the after partner to

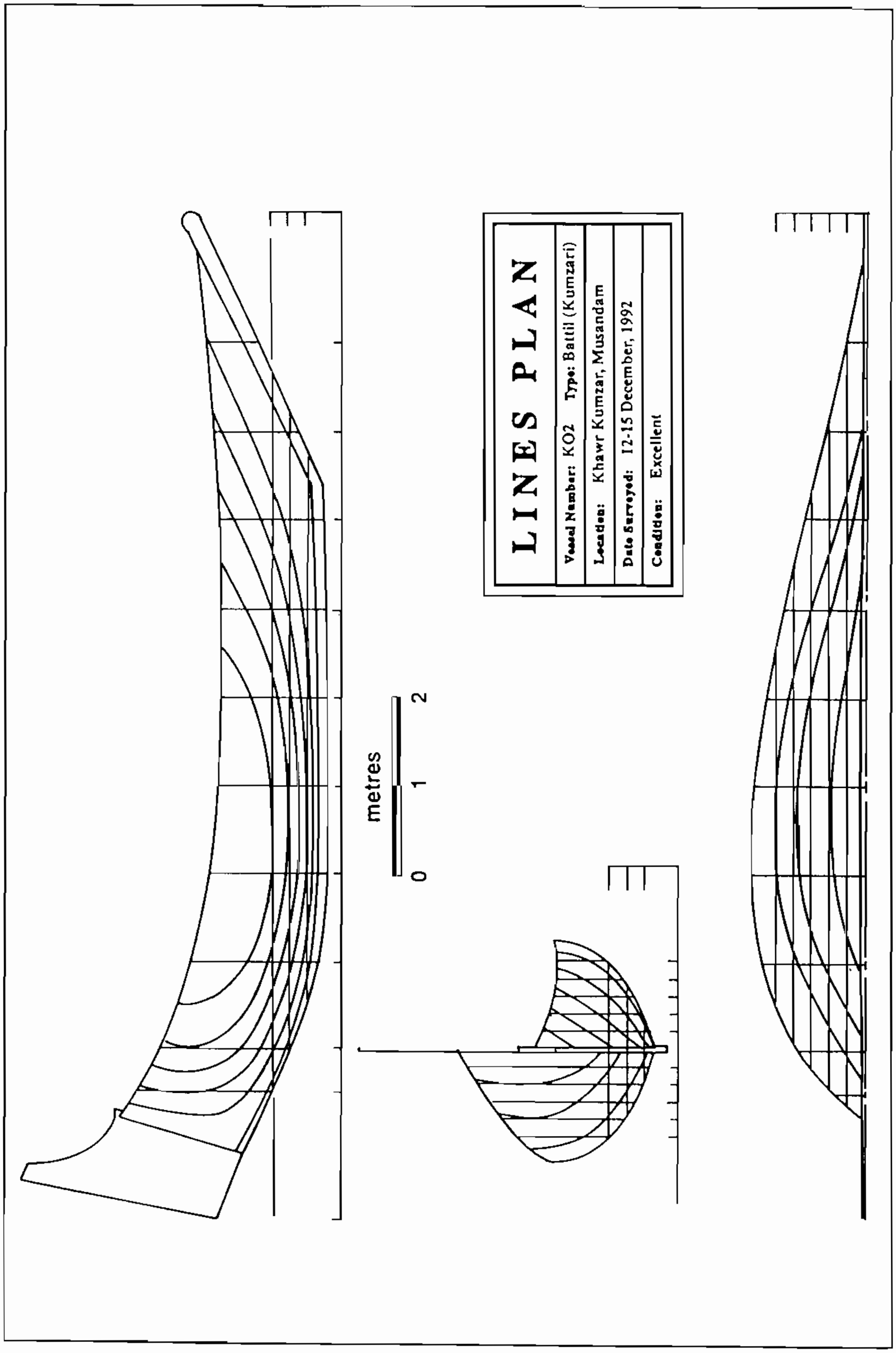


Figure 27. Lines Plan of Kumzari battil *KO2.*

the main beam of the afterdeck. Like its forward equivalent, it is set at a slightly oblique angle to the centre-line. The fore end of the timber is fitted in a notch in the after edge of the after

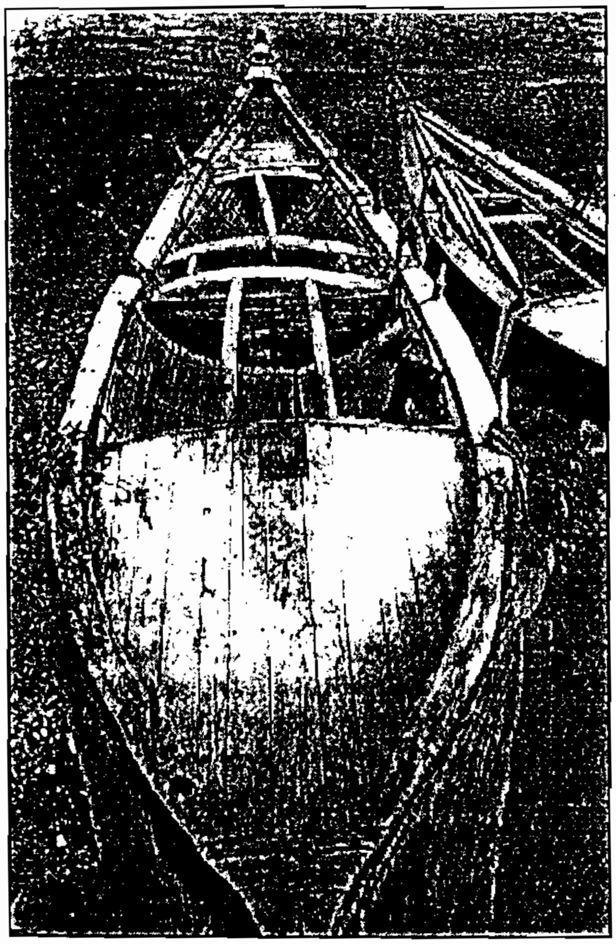


Figure 28. Kumzari* battil *KO2.

partner. Its aft end fits in a socket in the forward face of the afterdeck main beam. Its after end tapers in width and in thickness to fit in the socket cut in the forward face of the main beam. The forward end tapers in thickness only inside the notch. Both ends bear on their upper surfaces an incised 'X', the after end having two additional grooves above and below the mark.

The afterdeck is 1.805 m long on the centre-line. It consists of fourteen deck planks that are nailed to five deck beams with at least two nails for each beam and additional nails for splits in the timber. At frame station No. 14 the stringer becomes significantly wider and runs aft to the afterdeck main beam which fits in notches in the stringer. The notch in the stringer into which the main beam is fitted is 35 mm deep at its after face where the stringer resumes its normal (smaller) width, and 80 mm deep at its forward face. The rest of the beams fit into notches 15 mm deep. The deck planks are nailed into the rabbet in the main deck beam; the capping at the forward edge is also nailed to the beam. The deck has a pronounced camber, turtle deck fashion, in order to drain water rapidly towards the scuppers. Two scupper holes, one on either side at the forward end of the deck, are lined with PVC piping.

Inwales run along the sides from the main beam, meeting at the forward face of the apron. They are nailed to what must be the five aftermost frames; the five nails are spaced along the middle stretch of the inwales.

KO2: a *battil* (Figures 27 and 28)
Location: Khawr Koba beach, at the time of recording next to KO 1, second boat from the edge of the beach closest to the village
Length between perpendiculars: 10475
Maximum beam: 2371 mm
Accuracy of measurement: dimensions ± 5
scantlings ± 2

General description:
The vessel KO2, a *battil* according to the local people, is beached next to KO1, and is supported by shores lashed to thole pins on either side (Figure 28). It has *barasti*-lined open hold with partial decks at bow and stern and a compartment forward of amidships. Overall the vessel bears the mark of excellent craftsmanship and is richly decorated with carvings, shells, beads and goat-skin wrapped around the tip of the stem (Figure 29). Timbers are selected for curvature or shaped to fair curves, scarfs and notched pieces are carefully fitted, the afterdeck is strongly cambered, the foredeck exhibits a slight opposite camber. The hull is in very good condition and shows obvious signs of sustained maintenance.

Construction: (Figures 31 and 32)
The keel is deep and straight with a gentle curve at the stern. The stem is also a straight timber and exhibits a pronounced rake. The stem is sewn to

the plank ends.

The stem is of peculiar construction: the hood ends of the strakes meet at the stem and are sewn together; above the deck there is no internal timber (in-post) fitted in the angle formed by the converging hood ends but below the deck a heavy upright timber fills that space, apparently without extending all the way to the keel. The sewn joint is covered with a very thick, sticky and gritty black paste.

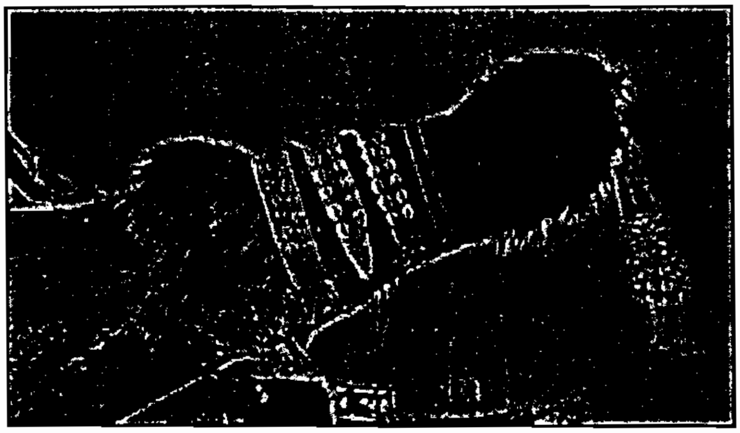


Figure 29. Bow of Kumzari **battil** *KO2 with shell, goatskin and ribbon decoration.*

The bow bears several ornaments. The tip of the stem is wrapped with goatskin, held in place with pieces of plastic string passing through a pair of holes in the end-post and tied together tightly. In addition, four bands are passed around the middle part of the goatskin cover securing it in place; three of these bands are decorated with double rows of cowrie shells (Figure 29).

Aft of the goatskin a double-horn ornament (*kalb*), carefully fashioned in wood and decorated with carved zigzag and straight lines, is fastened to the forward extensions of the caprails, one nail driven obliquely from the underside of each caprail and clenched on the horns' throat (Figure 30). The latter part of the bucranium bears deeply grooved traces of wear that form an 'X'.

Further aft, bridging the point where the caprails part, a semi-circular timber, carved at its after face with rectilinear designs, is nailed from above through the caprail and onto the framing timbers, with one nail on each side. While decorative, this timber functions as a breasthook.

The stern is also decorated. Abaft the laced hood ends, a tail, also fastened with lacing along its forward edge, forms a fin rising high above deck level. The tail consists of seven planks fitted edge-to-edge. The edges of the tail planks have hook-like indentations, one in each edge, that fit into each other in the vertical seams. Planks are held together by a pair of upper cheek knees and two pairs of lower cheek knees or splines. The cheek knees are fastened with nails driven from either side (through both cheek knee timbers of each pair and of course through the planking) and clenched on the opposite side. Some smaller round-headed nails in the upper cheek knee probably indicate later additions or repairs. Decorative bands of different materials and colours, including cloth strips with stitched on cowrie shells, are stretched around the high fin-like part of the tail.

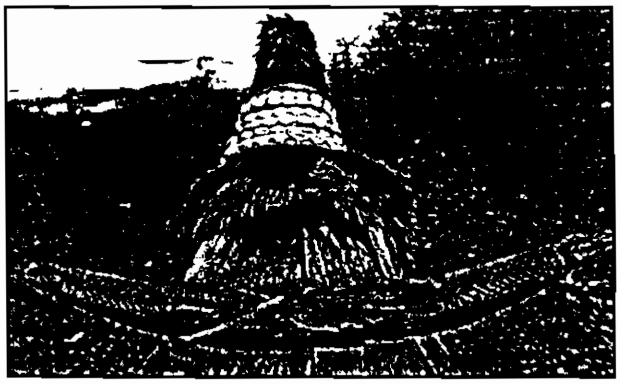


Figure 30. **Kalb** *of Kumzari* **battil** *KO2.*

Two breaks in the edge of the upper starboard cheek knee are repaired with stitches and nails. Evidence of wear in the form of fairly deep notches or grooves along the timber's outboard edge can be seen forward of the foremost repair. Both port and starboard upper cheek knees are

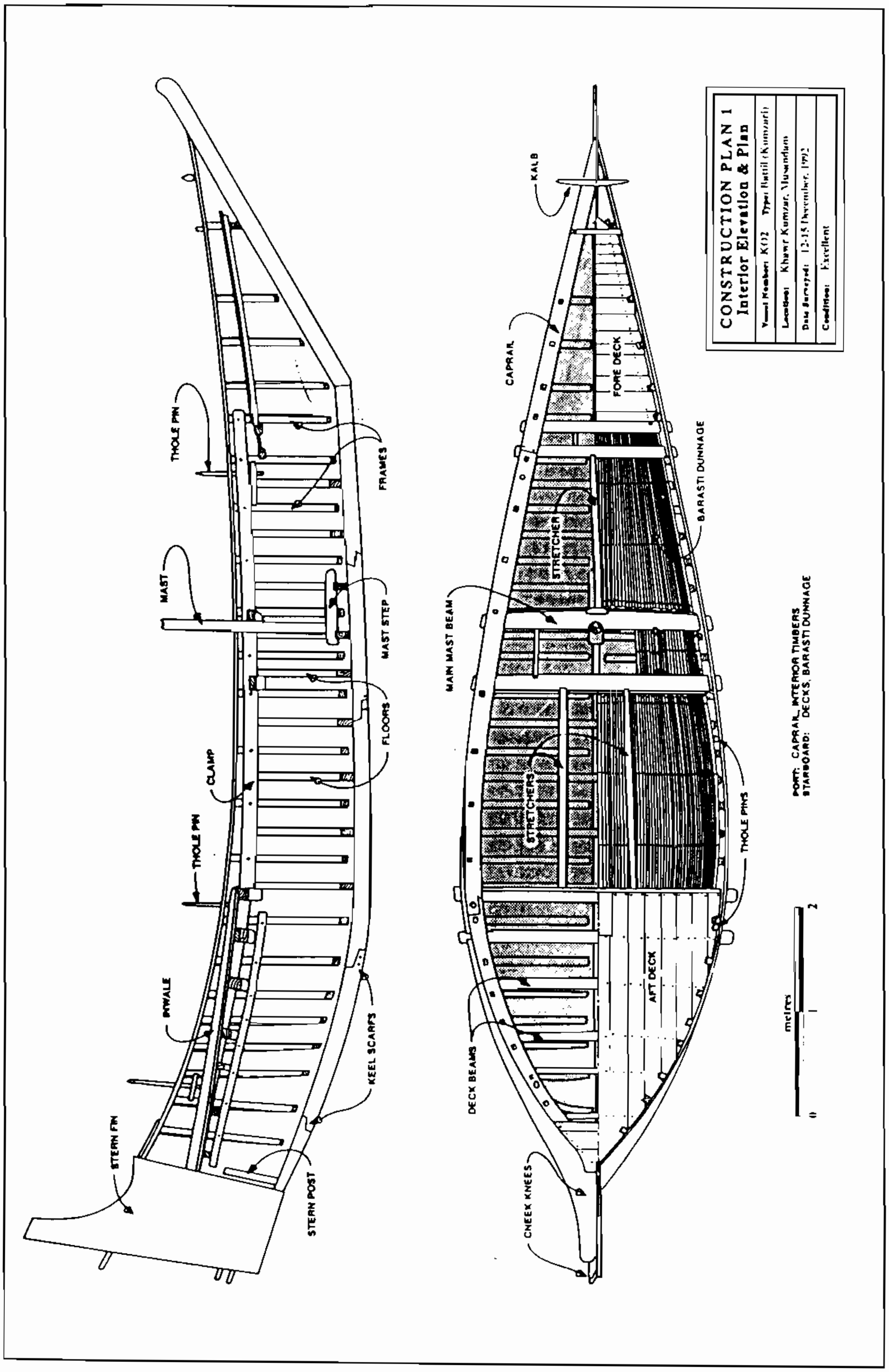


Figure 31. Construction elevation of Kumzari battil *KO2*

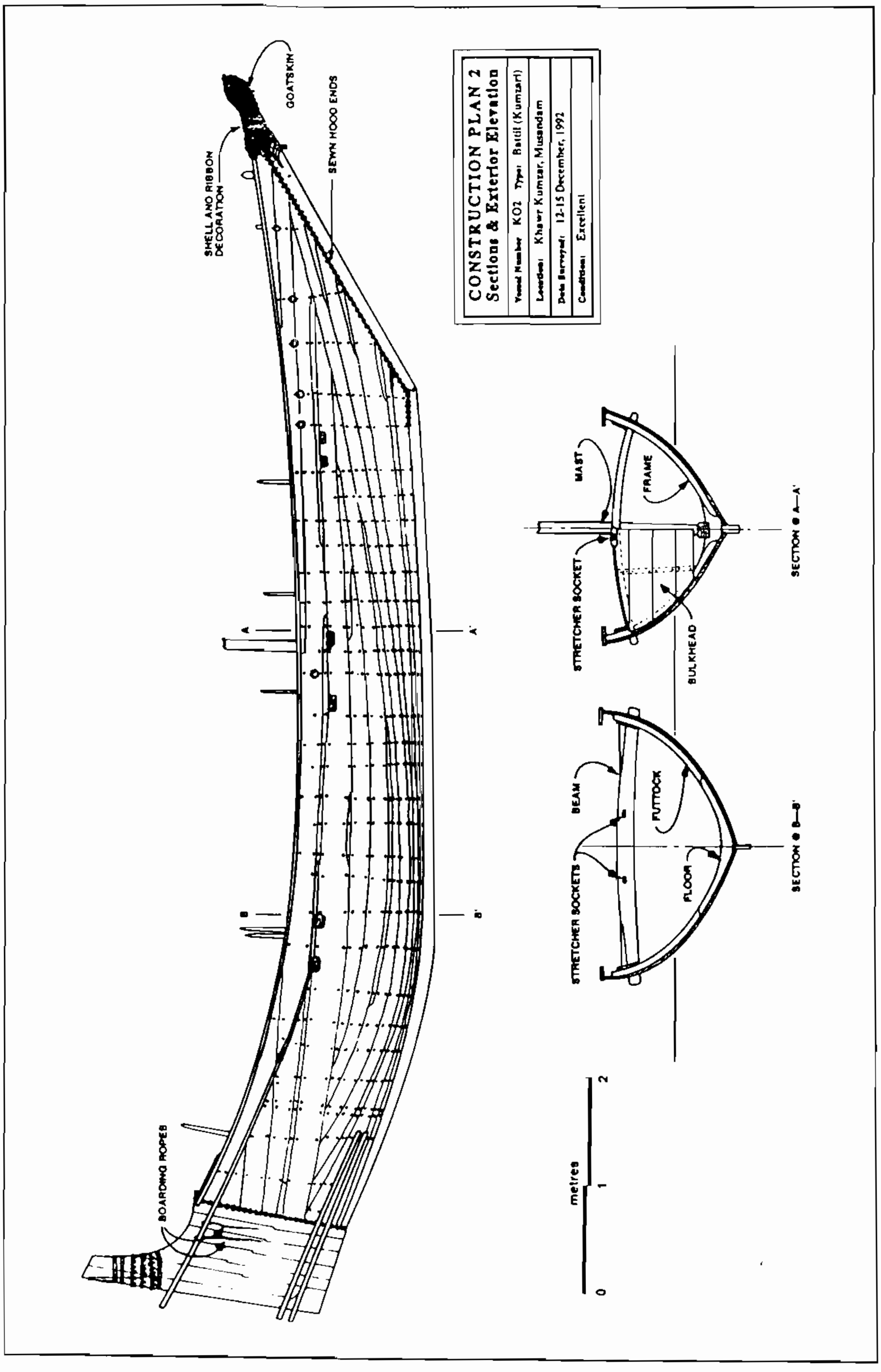


Figure 32. Exterior elevation and interior sections of Kumzari battil *KO2.*

pierced by a pair of holes at there middle part; each hole holds a nylon rope stopped with a knot at each end. The function of this configuration is uncertain; though a local fisherman demonstrated that its purpose is to help climb aboard.

The forward extension of the fin cheek knee runs below the caprail. On the port side it consists of two pieces. The after piece is scarfed to the rest of the cheek knee while its forward end is fitted and nailed onto a notch in the protruding end of the second deck through-beam. The forward piece is also fitted onto the protruding beam end and checked over the similarly protruding end of the afterdeck's main beam further forward. On the starboard side the cheek knee simply rests on the protruding beam ends (is not checked over them).

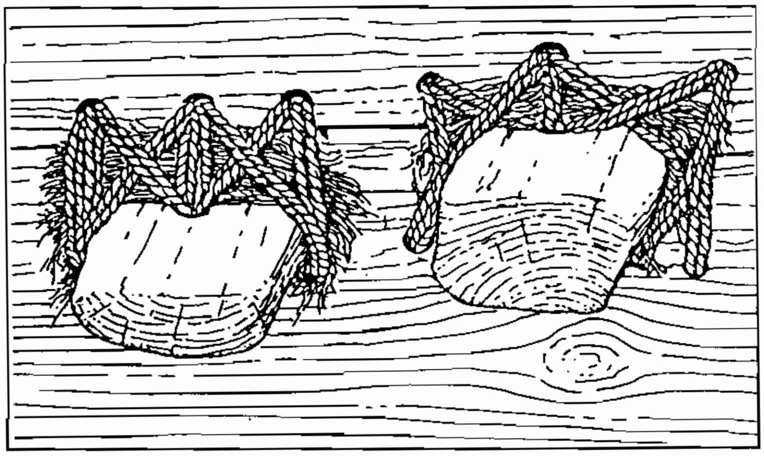


Figure 33. Typical stitching of through-beam ends to planks on Kumzari battil *and* mashua.

The foredeck comprises fourteen thwarts (instead of longitudinal planks) and a double ogee-shaped plank at its forward end. The deck thwarts are nailed on two beam shelves with two nails for each plank on each shelf. The shelves run parallel to the sides of the hull; there after ends fit into notches cut in the forward edge of the first through-beam while there forward ends rest next to each other on a small floor far forward at the bow. The entire deck lifts up at its after end. A small wooden handle fitted near the aft edge of the deck and positioned slightly to port, is provided for lifting the foredeck structure.

The foredeck has a slight 'negative camber'. Its overall length along the centre-line is 2060 mm from the tip of the ogee-shaped plank.

The forward through-beams were apparently once fastened in place by lacing; the holes in the planking, three above and three below each beam end, perhaps indicate the existence of a corresponding perforation through the beam itself. The entire area around the protruding beam ends is covered with thick black paste and some fibrous material, perhaps the remains of the lacing rope, impregnated with the same paste. The perforations mentioned above are for the most part covered by this substance but those still showing are all plugged without any rope passing through them. On many of the vessels at Kumzar, the stitching near the ends of through-beams was still in place (Figure 33).

Both through-beams exhibit significant camber, the camber being more pronounced in the after beam. It is noteworthy that the forward beam has a flat underside and a rounded top surface whereas the after beam has a flat top and a rounded bottom.

A rectangular notch, designed to take the forward end of a stretcher, is cut in the after edge of the second (after) through-beam slightly off-centre to port. The after edge also bears wear marks (seven deep grooves and some wider, shallower depressions). The deepest grooves are located on either side of the notch for the stretcher.

The stretcher spans longitudinally the forward part of the open hold. It runs at a slight angle to the centre-line towards the port side. Its forward end is notched into the second through-beam as described above. Its after end is tenoned into a special piece or block fitted in the forward face of the forward partner; slightly to starboard of the centre-line.

Two partner beams are located forward of amidships. Both beams have a pronounced camber. The forward partner is slightly heavier and has a semi-circular mast notch with decorative indentations on either side. Both partners are through-beams originally laced to the planks. The lacing has been removed, the openings plugged, and the area on the outboard surface of the planks around the projecting beam ends smeared with the black paste as described for the two forward through-beams.

The partners are connected with two thin carlings, one on each side. The port carling has its after end nailed into a notch in the forward edge of the aft partner. Its forward end is socketed into the aft face of the forward partner. The starboard carling has its ends fastened the other way round. The edge of a mat of *barasti* sticks is lashed to each of these carlings and then to the sheer clamp nearby. This configuration provides a storage bay for light equipment and supplies.

On the bottom of the boat below the partners a mast step is checked over the frames. It spans three frame stations, floors 10 and 12 and half-frames 11. The floors are notched to take the mast step and the underside of the mast step itself is cut to fit over these floors. The longitudinal edges of the mast step's upper surface are bevelled. The mast socket is rectangular and cut in the after part of the timber. A vertical drain hole runs from the bottom of the socket to the underside of the mast step.

Two bulkheads, one just forward of the forward partner and one aft of the after partner, delimit a small compartment between frame stations 11 and 14. The forward bulkhead has its planks nailed onto two stanchions stepped on the frames and notched in the under side of the partner. The nails are driven from the forward face of the planks and double-clenched on the after face of the stanchions. The upper edge of the top plank is arched to follow the camber of the partner. The bulkhead is not planked all the way down to the bottom of the hull; thus the compartment is not watertight. The after bulkhead is constructed in the same manner but has three stanchions instead of just two.

Two stretchers span the length of the after part of the open hold, on either side of the centre-line. Both timbers are rounded in section except for their ends that are squared to fit into the notches in the partner and sockets in the after deck main beam. The forward ends are incised on their upper face with an 'X' sign.

The afterdeck is cambered and comprises fifteen longitudinal planks carried on seven deck beams. The main beam is a through-beam rabbeted to take the ends of the deck planks, that are nailed in place. Its forward face is flat but its underside and part of its after face are curved. The main beam is checked through the planks. As with the forward beams and the partners, the beam must have been fastened to the planks originally by lacing but the cords have been cut off, the holes plugged, and the outboard area of the joint smeared with black paste. The protruding ends are nailed to the extension pieces of the upper fin cheek knees or wings that rest on them at that point.

Nailed on either end of the main beam, two wedge-shaped blocks act as barriers to water running off the deck into the hold and channel the flow to the scuppers located directly aft. A rectangular opening is cut in the planking on each side and a small block with a circular perforation inserted in the opening to protect the end-grain of the planking timber from rot.

The second deck beam is also a through-beam. This timber is not sufficiently arched to follow the camber of the deck; therefore an additional piece, rounded at its upper side, is fastened along the top side of the beam. The additional piece tapers in thickness towards the ends and is extended on both sides by short thinner pieces Once again the beam appears to have been originally laced but now the joint is simply smeared with thick, black paste.

The remaining deck beams, five altogether, are of progressively smaller dimensions and less pronounced curvature. They all rest on two partial stringers or beam shelves nailed onto the frames. On the starboard side the ends of the fourth and fifth beams rest in shallow notches cut into the beam shelf. Otherwise the beams simply rest on the beam shelf.

On each side of the afterdeck an inwale is nailed to the frames; the two timbers meet at a point just forward of the stern. They are decorated with a carved motif along there lower edge. There forward ends, just forward of the main deck beam, are scarfed to the top clamp that runs the entire length of the open hold on both sides.

A hatch, covered by two planks, is located in the centre of the forward end of the deck. Its function is not clear but according to the fishermen it is associated with the sail; it may originally have been the opening where the lower halyard block (*obaidar*) was fitted.

A number of iron rings are fitted at various points of the hull, inboard and outboard. On the exterior of each side there is one ring far forward at the bow, a row of four further aft, and one between the protruding ends of the partners. Inside the hull a ring is situated on the after end of the sheer clamps, and a single ring is fastened horizontally on the foremost plank.

Figure 34. Fisherman of Khawr Kumzar.

The framing pattern comprises thirty frame stations. The frames are alternating floors with futtocks and paired half-frames, except for those at the bow and at the stern. At the bow, the foremost frame station which consists of a very short angular floor is followed by at least two successive paired half-frames (abaft those the fixed matting conceals the bottom of the hull). At the stern the three aftermost frame stations (at least) are paired half-frames. An irregularity occurs also where the thole pin cleats span longitudinally the interspace among three frame stations and therefore the middle frame stops short below the cleat (on starboard at frame stations 16-18 and 10-12, and on port at frame stations 6-8).

The caprails extend from the stem, where port and starboard caprails converge, to the stern, where they end on either side of a short cross-piece or breasthook capping. Every other frame has its end notched into a corresponding opening in the caprail. At the foredeck and at the afterdeck all frames have their ends notched into the caprail. The only exceptions are frame station 25 starboard and frame station 26 port. Abaft both timbers the caprail exhibits a squarish opening, the starboard one being blocked halfway down so that it will not receive a standard thole pin. The port caprail comprises three pieces carefully scarfed as are the four pieces of the starboard caprail.

A sheer clamp runs on either side from the first through-beam to just forward of the afterdeck. The top clamps are nailed to every other frame and run above through-beams and partners. They are narrow at their forward ends but widen progressively towards the stem. Their after ends are scarfed to the inwale.

The fishermen at Kumzar were very helpful, not only in patiently demonstrating and explaining how their boats worked, but also in frequently providing us with fresh fish, tea and coffee, and offering their beach shelter to us, should it rain.

We are indebted to them for their cooperation (Figure 34).

SEWN *SAMBUQ*

In 1985 Cmdr Tilley had secured for the Exeter Maritime Museum (UK) an example of a sewn *sambuq* from Tarqa on the Dhofar coast. The *sambuq* of the Dhofar coast in no way resembles the larger sailing or motorised *sambuq* of the Batinah coast. The Dhofari *sambuq* is a small double-ended open boat, sewn together (Figure 35). Traditionally, the rope would have been made of coir (coconut fibre) but at least some of this vessel was sewn with synthetic fibre rope.

The length of this vessel (EX1) is 8.820 metres between perpendiculars (the extreme ends of the sheer strake) and a maximum beam of 1.600 metres (Figure 36). The keel is straight and both the stem and sternpost are raked, the stem at about 32° to the line of the keel and the sternpost about 55°. There are five planks per side, sewn together along their edges with continuous light three-strand rope. Dowels have been driven in places near the plank edge, obliquely through one plank and into the edge of the plank below. During the building process, which of course is shell-first, these dowels help keep the plank edges locked in position while they are sewn together. The rope is lashed through opposed pairs of 7 mm holes spaced 40 to 70 mm apart along the edges of the planks. On the outside of the planking the opposed holes are linked by a recess cut for the lashing rope, so that it does not stand proud of the surface. On the inside the rope is tightened over a coir fibre padding running along the plank seam. The hood ends are sewn to the stem and sternpost, but with the fibre padding on the outside.

Unlike the *badan*, *baggarah*, *battil* and *mashua* examined in northern Oman, where the configuration of the lower planking was largely drop strakes with ends running out into the upper strakes, each strake on the sewn *sambuq* is continuous from stem to sternpost (Figure 35). Some straight scarfs appear in the plank strakes, sewn like the seams between strakes. Through the midship sections there is a hard chine on each side between the second and third strakes, which runs out towards the ends of the vessel. There is a lashing on the sheer strakes just aft of the stem reinforcing the sheer strake connection to the stem. Inboard of the gunwale a clamp is fitted, nailed to the sheer strake with clenched iron nails. Wear on the edge of the sheer strake is not echoed in the clamp, indicating the clamp to be a new addition or repair. The futtock timbers are checked around the clamp.

There are seven grown floor timbers, the five midships ones extended by grown futtocks fitted with a short straight scarf. Between each set of floors are pairs of grown half frames, or fillers. Like the planks, the frames are lashed into the vessel.

There are five thwarts, lashed to the hull planking at the level of the fourth strake from the keel, checked around the floor/futtock frames. Near each end of the vessel is a small dicky seat, lashed in a similar fashion like the thwarts, but not checked around the floor timbers. The forward seat is higher than the aft one, being lashed near the lower edge of the sheer strake.

Along each gunwale are nailed four thole pin blocks. They are worn on the side forward of the pin position, indicating the oars work forward of the pins.

Hydrostatic Analysis

Of the vessels whose lines were recorded, it is possible to evaluate by computer the hydrostatics, stability, approximate powering requirements and relative suitability of the design for its intended use. Measured dimensions of each vessel were organised into a table of offsets which described mathematically (as points in space) the shape of the vessel. These points were then fed into the computer programme which then produced, by a series of mathematical polynomial iterations, a lines plan of the vessel.
The underwater form of a hull, linked with its

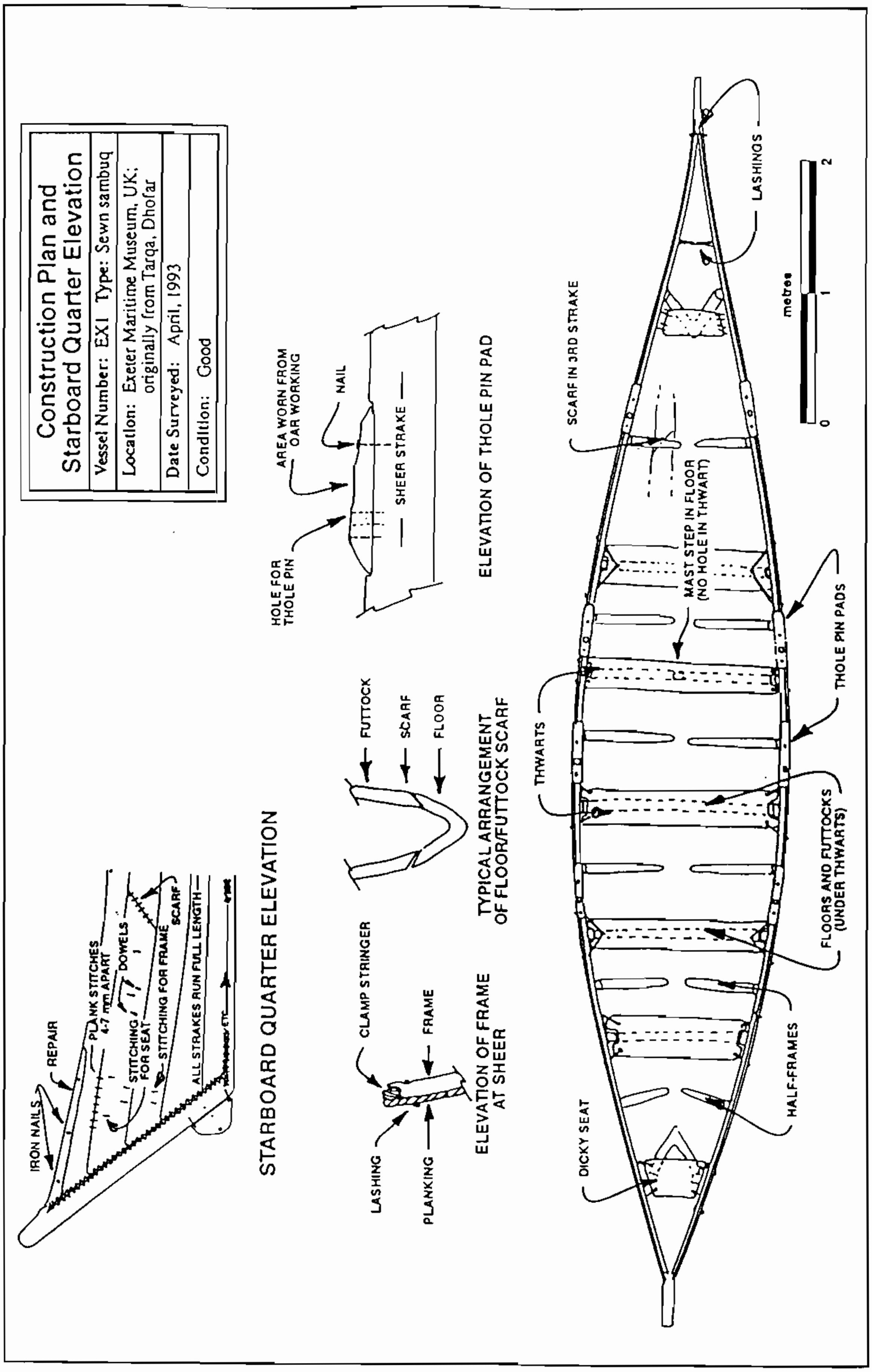


Figure 35. Construcion Plans of sewn sambuq *from Dhofar at the Exeter Maritime Museum (EX1).*

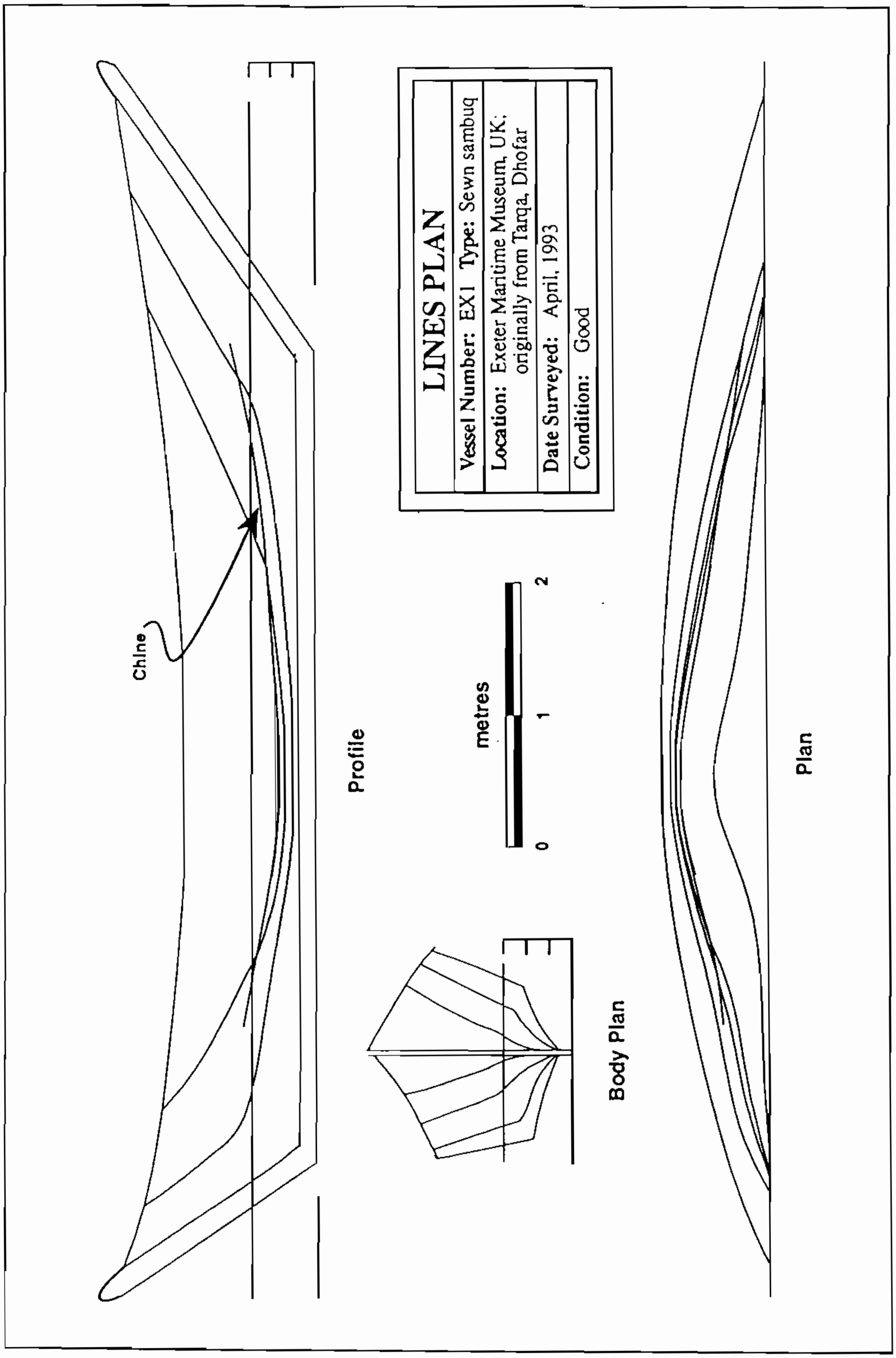


Figure 36. Lines Plan of sewn sambuq *(EX1).*

weight (displacement) and centre of gravity largely determines the individual characteristics of that particular hull. Each set of lines plans therefore produces a unique set of performance parameters. The computer is a very valuable tool for such evaluation, since it is relatively easy to rapidly calculate how changes in trim, displacement or centre of gravity may effect the performance of a vessel. The danger in the method lies in the ability of the computer to generate so much data that the sheer volume of data becomes unmanageable. It is therefore important that the number of variables is strictly limited. Thus for each of the vessels that were analysed, only one of numerous possible design waterlines was chosen, the centre of gravity was assumed to be at the waterline, and the fore-and-aft trim adjusted to what appeared visually correct. In some cases, choosing the correct (i.e. true) waterline presented no problem, as evidence of its position still existed on the hull. In other cases, such as in *houri*, which would likely have been operated at several different loadings (and therefore different waterline positions), an estimated position was chosen.

Even with the aid of a computer the analysis of hydrostatics and stability is an extremely complex and subtle exercise. For those versed in the esoteric mysteries of naval architectural design, the computer-generated statistics are shown in Appendix C. The most important parameters to consider for our purposes are the *waterline length, hull draught, displacement, wetted surface area, prismatic coefficient, BM transverse and the righting moment at one degree.*

Waterline length has a direct bearing on the speed potential of any vessel. In general, the longer the *waterline length*, the greater the maximum speed. This stems from the fact that the maximum speed for a displacement boat is about that of a water wave in deep water that has a wave length equal to the *waterline length* of its hull. The speed/length ratio, which is really the ratio of the speed to the square root of the length, for such a water wave is given by the expression $V/\sqrt{L} = \sqrt{g/2\pi}$ (Garrett, 1987:129). If the speed (V) is given in knots (nautical miles per hour) and the length (L) in metres, as the waterline lengths are in the lines plans, and 'g' is the acceleration of gravity, the resulting ratio is 2.34. In other words, the theoretical maximum speed in knots for any displacement (non-planing)vessel is 2.34 times the square root of the waterline length (in metres). Taking for example the Kumzari *battil* KO2, with a *waterline length* of 8.2 metres, the maximum expected speed (V) would be given by $V=\sqrt{8.2} * 2.34 = 6.7$ knots. Maximum potential speed for each of the measured vessels has been calculated and appears in Appendix C.

Another important parameter is the *prismatic coefficient* (C_P)which is a number loosely describing the shape of the hull, or more specifically the fineness of its ends. There exists an optimum *prismatic coefficient* for any given speed. It is generally said that for sailing vessels which normally operate at low speeds, *prismatic coefficients* should be in the range of 0.52 to 0.58. Tank tests have shown the optimum *prismatic coefficient* remains fairly constant below speeds of $V/\sqrt{L}=2.0$, but rises rapidly thereafter. This would suggest that the Kumzari *battil*, with a low C_P of 0.503, if pushed to its maximum theoretical hull speed of 6.7 knots, would require relatively more power to drive it than, say the *badan* hulls KM1 and AT8, with C_P's of 0.566 and 0.541 respectively.

Another parameter, *wetted surface*, bears directly on powering requirements, as one component of the total drag generated by a moving hull. The amount of friction drag is directly proportional to the area of the under water surface. It follows then that vessels with larger amounts of *wetted surface* will require more power to drive them than those with less *wetted surface*.

Displacement (weight) of a hull also effects powering requirements, with heavier hulls requiring more power to drive at a given speed than lighter ones. There are however, advantages to greater *displacement*, such as greater cargo capacity and in sailing vessels, the ability to carry more sail due to increased stability.

This increase in stability with increase in displacement is linked to the *BM transverse*, or the transverse metacentric height. The *BM* is influenced primarily by hull shape and the position of the vertical centre of gravity within the hull, and though the determination of *BM* is a complex issue, one can state that the higher the *BM*, the greater the stability.

The *righting moment* is an indication of the force acting on a heeled hull to return it to the upright position. A hull with relatively high *righting moment* is more stable than one with a relatively low moment. It is also true however, that vessels with relatively high righting moments will be less comfortable in a seaway.

To compare vessels of different designs and sizes is a complex exercise, but close study of the data generated in the hydrostatics analyses of the measured vessels is useful in evaluating their relative capabilities.

Conclusion

Oman provided a wealth of material for the expedition. Some of the discoveries were expected, while others, such as the apparent revival of *shashah* building, the resurgence of a boat building industry in Sur and the existence of *battil* or there close cousins, were complete surprises.

The organisational and logistical problems encountered, particularly in the early stages of the project, while disruptive were also valuable learning experiences enabling better planning should we be able to work in Oman again.

The degree of difficulty involved in frequently moving the base camp was unexpected, and was due mainly to the time required to find another suitable site. Other unexpected, though mostly pleasurable occurrences were the continual visits by Omani villagers and townspeople to the campsites. Sometimes they came for coffee and conversation, sometimes with gifts, always with curiosity, friendliness and generosity. At one stage there were so many that we had to assign someone the duty of looking after the visitors, so the rest of us could get on with our work of recording boats.

Several private businesses in Oman embraced the project enthusiastically and gave very valuable assistance. All are interested in seeing the project continue and expand. The staff and Principal Investigator developed working relationships within the Omani business community which should be cultivated. Proposals for 1993 are being prepared for submission to private businesses in Oman who either provided support for the 1992 project, or expressed an interest in being involved in future phases of the work.

Much work remains to be done. The two *baggarah* in Shinas need further investigation and documentation. The one largely buried in the beach sand may be worthy of rescue and restoration and should be studied more closely. While we were in Oman, high-ranking officers of the Royal Oman Navy expressed an interest in identifying and collecting for preservation good examples of Omani traditional vessels.

Due to time and financial constraints, the teams were not able to explore the coast south of Al Ashkharah that, from independent reports promises to be interesting and rewarding. The Dhofar coast also requires investigation, though Commander Tilley some years ago secured a typical sewn beach boat (*sambuq*) from that area, now in the Exeter Maritime Museum, U.K., and reviewed ealier in this report. A survey of the Dhofar coast to determine what else is there and in what numbers, needs to be done.

In the Musandam, the only place visited was Khawr Kumzar. If the wealth of maritime ethnographic information available there is any indication, it would appear that entire region is a very rich resource for such studies. The project team began a linguistic study of the local terminology used to describe parts of vessels and their functions. This needs to be continued. The Kumzari vessels appear to show a minimum of western influence, probably due to the general inaccessibility of the region, and therefore would bear continued rigorous examination.

Too little time was available during the 1992 field season to study and document completely the boat building industry in Sur. From the intense activity there it would appear Sur has returned to its former glory and productivity as a boat building centre. Sur warrants very close attention for the information to be gained from this boat building activity.

We would like therefore to continue the programme. The archaeological and ethnographic potential of Omani shores is immense. It is hoped that with the experience gained, the contacts made, and with much of the logistics support in place (all camping and survey equipment have been put into storage with two of the Omani supporters) we will be able to continue the project in 1993 and beyond. The project would be very pleased to develop close working relationships with representatives from the government, military and Sultan Qaboos University, and would very much benefit from Omani representatives from any or all these organisations being part of the field work. The project would of course provide all daily living support such as accommodation, food and transportation for these representatives. It is hoped that the mutual benefits of such a cooperative programme can be realised through the further development of the project.

APPENDIX A

Omani Boat Types

Badan — There are two basic types of *badan*, the fishing *badan* and the larger cargo *badan*, also called *'uwaissiyyah*. The fishing *badan* is characterised by a high pointed stern fin, a clipper-type false stem and twin skegs or grounding keels. It has no true keel, but a keel plank. The hood ends of the planks are usually sewn to the system of ropes working a tiller fixed in a reverse position (pointing aft). These vessels may be sailed or rowed. The cargo *badan* is very much beamier and deeper than the fishing *badan*. It has a true keel, no twin skegs and its stern fin is truncated, but the form of the clipper false stem is retained as in its smaller cousin. Steering system is similar to the fishing *badan*.

Baggarah — A long, narrow vessel with long raking stem and radically upswept stern sections. Very similar to the *battil*, but without any club-shaped stem profile. The stern fin differs from the *battil* in being less vertical. *Baggarah* may be rowed or sailed.

Baghlah — Large cargo vessel distinguished by its elaborately decorated high poop and quarter galleries, strongly reminiscent of 18th and 19th century European sailing ships. Two or three masts.

Battil — Traditionally, a type of double-ended vessel with club-shaped stem head and stern profile in the shape of a stylised dog's head. The vessels noted at Kumzar, and locally called *battil* are not of the classic variety, though at least one had the distinctive 'dog's head' stern profile. All others preserved a derivative of the distinctive profile, and a vestigial club-shaped stem. The end of the stems on all these *battil* were covered in goatskin. The vessels called *battil* at Kumzar appear to the authors to actually be a hybrid of *battil* and *baggarah*. All the Kumzari *battil* were elaborately decorated with cowrie shells, ribbons and tassels, as well as the goatskin, carved panels and designs picked out with brass studs.

Boom — A double-ended vessel having a sharply raking stem and less sharply raked sternpost. The stem is normally painted with a black and white motif. One or two masts. No *boom* were examined during the 1992 field work.

Ghanjah — Very similar to the *baghlah*, but less elaborately decorated. Its stem-head decoration, concentric circles surmounted by a trefoil crest, is distinctive.

Houri — Dugout canoe, extended dugout, or boat owing much to its design to a dugout. On the Batinah coast, the term refers to any small boat. Fully-planked *houri* and even fibreglass *houri* were noted. The *houri* dugout hull is always double-ended, but often has a built-on transom used to mount an outboard motor.

Jalibut	A transom-sterned vessel with vertical stem.
Karib	Large fibreglass dinghy used for fishing. Powered by outboard motor. These have generally replaced the wooden *houri*, launches and *badan* used for fishing in the past.
Launch (or *lansh*)	Small motorised vessel. Seems to be a generic term, applied to large *houri*, *shu'i*.
Mashua	'The term *mashuwah* is not heard frequently in Oman, where it is generally used to refer to small longboats, generally about 25 feet curved or vertical stems, and no deck. There is nothing except propelled by oars but, like the huri, may be fitted with mast and the Gulf, would often use his time to advantage by building a denoting any small, deckless, square-sterned boat, and has even been heard applied to an aluminium craft of that form' (*Oman A Seafaring Nation*, 1979:153). At Kumzar, however, the fishermen use the term *mashua* to denote specifically the small double-ended, fin-tailed oared wooden craft that they employ in coastal fishing.
Shashah	A small one or two-man vessel made from the spines of date palm leaves. In the report these vessels are sometimes referred to as 'reed' boats, but the construction material is not reed (a member of the grass family) but the rachis of date palm leaves.
Shu'i	A transom-sterned vessel with straight stem ending in an ogee curve. The sheer strakes sweep back to a high quarter deck and project beyond the transom, much in the style of 16th century European caravels or some Chinese junks. They are common in Oman, and much used for fishing.
'Uwaissiyyah	See above under *Badan*.

APPENDIX B

Terminology

The terms given below are defined as used in this report. Due to the unique nature of some parts of Omani vessels, the definitions in some cases may differ slightly from tradition. Words used in definitions which also appear in the terminology list are italicised.

Abaft	Toward the *stern*, at the rear of.
Aft	Denoting any part of a vessel's hull *abaft* the middle.
Amidships	The middle of a vessel, as regards both length and breadth.
Apron	A timber conforming to the shape of the *stem* (or in double-ended craft, the *sternpost* as well) and fixed inboard of the *stem* or *sternpost*. It is used to reinforce the *scarf* joints in the *stem* or *sternpost* and to provide backing for the ends of the planks.
Athwartships	At right angle to the centre-line of the vessel, in plan view. Also called athwart.
Beak	A thin planked vertical structure (*false stem)* at the *bow*.
Beam (1)	The width of a vessel, designated 'maximum beam'.
Beam (2)	An *athwartships* timber to which *deck plank* are fastened.
Beam shelf	A timber running longitudinally along the inside of a hull. Usually fastened to the *frames*, and on which the beams rest and are fastened.
Belay	To tie off a rope or line.
Bilge	That part of a vessel's bottom on either side of the *keel* which has more of a horizontal rather than vertical direction.
Bitts	Square timbers fixed to the *beams* used to secure rigging and ground tackle. At times they are extensions of *frame* timbers.
Block	A pulley.
Bollard	A vertical belaying *bitt* placed on the *deck* or rail.
Bow	The forward part of a ship, terminating in the *stem* or *beak*.
Breasthook	A V-shaped timber fixed *athwart* the ends of a ship, serving to lock the two sides together.
Breasthook capping	Timbers fastened athwartships at the end of a vessel, usually atop the *gunwale*. Functionally, it serves as a *breasthook*.
Bulkhead	Transverse or longitudinal partitions within a vessel.
Caprail	A timber laid horizontally over the *sheer strake* and *frame* heads. In Omani boats, the heads of the *filler frames* are usually tenoned into the *caprail*.
Carlings	Timbers laid *fore-and-aft* and let into the *beams*. They form part of the *deck* substructure.
Ceiling	The planking or fixed lining inside a vessel's *frames*.
Cheek knee	*Knee* fitted in the angle of the *bow* and *beak*, or of the *stern* and *stern fin*, and acting as a bracket to brace the structures.
Clamp	A *strake* of timber fastened to the inside face of the *frame* timbers , running *fore-and-aft*, often supporting the *beam shelf*. See *inwale*.
Counter stern	Usually, the long overhanging portion of the *stern abaft* the rudder of a vessel. In this report, *counter stern* refers to the *stern* of a *houri* which has

	been modified to mount an outboard motor.
Cross bitt	An *athwartships* timber fastened on the *gunwale* which is used for *belaying* anchor *warps*, fishing nets, etc.
Deadrise	In section (body plan) view, the angle made by the bottom of a vessel relative to the horizontal.
Deck	The horizontal platform in a vessel.
Double-clenched	Denotes nails which are driven clean through the timber they are fastening and have there points then bent over and hammered back into the wood.
Double-ended	A vessel which is pointed at *bow* and *stern*, without a transom stern.
Dowel	A wooden pin, fastening or nail.
Drop strake	*Strakes* or *planks* which do not run the full length of the vessel, but are fitted in the midships sections and taper towards there ends, feathering into the upper *strakes*.
Dugout	A type of vessel the main hull of which is fashioned from a single log. Dugouts are often enlarged by the fitting of additional *strakes*.
Dunnage	Light timber, branches, etc. used to line the inside of a hull to protect the planking from being damaged by the cargo.
False stem	A non-structural timber fitted forward of the true *stem*.
Faying surface	The fitted surfaces of two timbers.
Filler frame	*Frames* fitted between *floors*, but not crossing the *keel*. A *half-frame*.
Floor	*Frames* which are fixed *athwart* the keel.
Fore	A term used to designate parts of a ship near the *stem*, or in that direction, as opposed to *aft*..
Fore-and-aft	From *stem* to *stern*; lengthwise, parallel to the vessel's *keel*
Frames	Those transverse girders forming the ribs of a hull and extending from the keel up the sides.
Freeboard	The minimum distance from the waterline to the *gunwale*.
Futtock	A *frame scarfed* onto the end of a *floor*.
Gunwale	The upper outer edge of the *planksheer*.
Half-frame	A *filler frame*.
Halyard	The rope used to haul up a sail. Also spelled 'halliard'. The word is a contraction of the terms 'haul' and '*yard*'.
Hawse hole	Apertures for the anchor tackle to pass through, or in *dugouts*, to be fastened.
Hold	General term for the spaces designated for the stowage of cargo.
Hood ends	The ends of planks where they fit into the *rabbet* of *stem* and *sternpost*.
Inner post	A piece of timber *fayed* to the foreside of the main *sternpost*. Also called in post.
Inwale	A piece of timber fastened on the inside face of the *frames* of an open boat and extending along the *top strake* of the planking. Serves the purpose of the *clamp* in decked boats.
Keel	The main and lowest timber in a vessel, running longitudinally from the *stem* to the *sternpost*.
Keelson	The longitudinal timber fixed exactly over the *keel*, laid upon the *floors*. Not usually found in Omani boats.
Knee, hanging	An angular-shaped timber used to reinforce a joint such as a *deck beam/ frame* joint, in a vertical direction.
Knee, lodging	An angular-shaped timber used to strengthen horizontal joints.
Limber hole	Holes cut through the bottom edge of *floor* timbers, in order to allow water

	to run to the pumps or bailing station.
Mast	A straight piece of cylindrical timber set up vertically or nearly so and used to support a *yard*.
Mast beam	The *beam* to which the *mast* is secured or through which it is stepped.
Mast step	A heavy timber fitted over the *floors* to receive the heel of the mast. It functions to distribute the forces of the mast compression to the vessel.
Obaidar	The lower *halyard block* of an Arab vessel, fastened to the hull structure at deck level.
Ogee	A continuous double curve, convex and concave.
Ogee arch	The shape formed by the union of two opposing ogee curves meeting at its apex.
Partner beam	A heavy beam in way of the *mast*.
Planksheer	A horizontal fore-and-aft timber which forms the outer limit of the upper *deck* at the sides. Where there is no *deck* (as in the open portions of *badan* and *battil*) it is a *caprail*.
Port	The left side of a vessel.
Quarter	The upper part of a vessel near the *stern* or *transom*.
Rabbet	A shoulder or recess on the edge of a piece of wood (such as a *keel*, *stem* or *sternpost*) to receive the edge of another piece of timber.
Rachis	A spine. In this report, the term refers to the spine of a date palm leaf, used for *shashah* construction or as *dunnage*.
Riser	A light *stringer* fastened to the inside of a boat on which the *thwarts* rest and are fastened.
Rivet	A metal pin used for connecting the various parts of a vessel. After hammering through the parts, the pointed end is flattened over a *rove* to secure the fastening in place.
Rove	A metal washer fitted over a *rivet* after it is hammered home. The point of the *rivet* is flattened against the rove.
Scarf	A joint by which the ends of two structural timbers are united so as to form a continuous piece.
Scupper	A drain hole through a vessel's side at *deck* level to carry off rain or seawater.
Sewn boat	Any vessel in which at least some of the fastening of the structure has been done by means of binding, lashing, lacing or stitching with rope, cord, thread, fibre, sinew or root.
Sheave	A grooved wheel in a *block*, *mast*, *yard* etc., over which a rope passes.
Sheer clamp	A fore-and-aft timber fastened on the inside face of the framing, running along the *sheer strake*. See *inwale*, *clamp*.
Sheer line	The upper outer edge of a hull.
Shell-built	Denoting a vessel constructed by planking first, them fitting the *frames*. See *skeleton-built*.
Skeleton-built	Denoting a vessel in which the hull planking has been applied over a previously set up permanent framing structure.
Skeg	A shallow *keel* running longitudinally along the bottom of a hull.
Spline	A long piece of timber, generally small in sectional dimension.
Stanchion	A vertical structural timber supporting bulwarks or *washstrakes*.
Starboard	The right side of a vessel.
Stem	The upright post of the *bow*.
Stern	The after part of a ship or boat

Stern fin	The high, thin, vertically-planked stern structure on *badan*, Kumzari *battil* and *mashua*, or *baggarah*.
Sternpost	The vertical timber to which are fastened the aft ends of the plank *strakes*.
Strake	A group of *planks* abutting each other and running the length of a vessel.
Stretcher	A light timber against which an oarsman braces his feet.
Stringer	A timber fastened longitudinally along the length of the vessel on the inside of the hull framing.
Taking lines off	The process of measuring and recording the shape of a vessel.
Thole pin	A wooden pin fixed to the *gunwale*, functioning as a pivot against which an oar works.
Throat	The midships part of a *floor timber* over the *keel* where its depth is greatest.
Thwart	An *athwartships* bench in an open boat
Top strake	The top-most *strake* on a vessel, also called *sheer strake*.
Treenail (trunnel)	A wooden nail (*dowel*) used to fasten parts of a vessel together.
Wale	The *strake* of wood running along the outer edge of the *gunwale*
Warp	Rope used for anchoring.
Washstrake	A light strake , usually fitted on a dugout, raising the *freeboard*.
Wing stem	A horizontal V-shaped piece of timber fitted at the bow (or at times the stern) of a vessel (usually in extended dugouts). The ends of the washstrakes are fastened to the wing stem.
Yard	A long, nearly cylindrical piece of wood used to support a sail.

APPENDIX C

Hydrostatic Analyses

In each case where the lines (form) of a vessel were recorded, computer analysis has been done in order to evaluate on a comparative basis the handling characteristics, stability, powering requirements and carrying capacity of each vessel. The analysis was carried out by a Macintosh IIsi computer using the Prefit and MaSurf naval architecture software. These programs were created primarily to assist naval architects in designing boats but have been adapted by the Principal Investigator for use as information storage and evaluation systems for application to existing traditional boat designs.

The PreFit program is merely a device to enable existing measurements of the form of a vessel(such as a table of offsets) to be input into the computer for further refiement and evaluation by the MacSurf program. TheMacSurf program analyses the form of vessels and makes calculations concerning stability, handling and performance potentials based on the form of the vessel and an (optional) input of centre of gravity which must be calculated manually. The program will, however, automatically assume a vertical centre of gravity value based on the form of any particular vessel if one is not input by the operator. The vertical centre of gravity is of course crucial to stability calculations. Despite its being a tool for the design and comparative analysis of modern racing boats, the MacSurf program is a useful tool in comparing traditional boats to one another.

The following pages display the computer printout of the analysis for each vessel.

Hydrostatic Analysis of *houri* AH1

```
$ CALCULATE INTERMEDIATE RESULTS HYDROSTATICS
$ * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
v1=((sa0+sa10)*0.5)+((sa1+sa9)*1.5)+((sa0.5+sa3+sa5+sa7+sa9.5)*2)+((sa2+sa4+sa        4.395
v2=(v1*Spacing)/3                                                                        1.104
Lb=sa0.5+(sa1*1.5)+(sa2*8)+(sa3*6)+(sa4*16)+(sa5*10)+(sa6*24)+(sa7*14)+(sa8*3.         21.762
b1=((wlb0+wlb10)*0.5)+((wlb1+wlb9)*1.5)+((wlb0.5+wlb3+wlb5+wlb7+wlb9.5)*2)+((v         23.855
Vb=(((sa0*cav0)+(sa10*cav10))*0.5)+(((sa1*cav1)+(sa9*cav9))*1.5)+(((sa0.5*cav0.        -0.460
ws=((igir0+iglr10)*0.5)+((igir1+igir9)*1.5)+((lgir0.5+igir3+lgir5+lgir7+lgir9.5)*2)+((  29.587
ts=((tgir0+tgir10)*0.5)+((tgir1+tgir9)*1.5)+((tgir0.5+tgir3+tgir5+tgir7+tgir9.5)*2)+(  49.483
Lm=dr0.5+(dr1*1.5)+(dr2*8)+(dr3*6)+(dr4*16)+(dr5*10)+(dr6*24)+(dr7*14)+(dr8*           36.353
Lp=((dr0+dr10)*0.5)+((dr1+dr9)*1.5)+((dr0.5+dr3+dr5+dr7+dr9.5)*2)+((dr2+dr4+dr(         7.299
Lf=wlb0.5+(wlb1*1.5)+(wlb2*8)+(wlb3*6)+(wlb4*16)+(wlb5*10)+(wlb6*24)+(wlb7*1          117.951
L   =spacing*10                                                                          7.536


$ CALCULATE FINAL VALUES HYDROSTATICS
$ * * * * * * * * * * * * * * * * * * * * * * * * * *
Length water line             m = L                                                      7.536
Max cross section          sq m = maxa                                                   0.230
Hull draught                  m = maxd                                                   0.282
Beam waterline                m = maxb                                                   1.131
Displacement                 kg =  v2 * 1025                                          1131.698

LCB aft of st0                m = (Lb/v1)*Spacing                                        3.731
LCB  as percentage              = 10* (Lb/v1)                                           49.514
VCB   below dwl               m = Vb/v1                                                 -0.105

Waterplane area            sq m = b1*Spacing/3                                           5.993
LCF aft of st0                   m = (Lf/b1)*Spacing                                     3.726
LCF as percentage               = 10*(Lf/b1)                                            49.444

Lateral plane area         sq m = Lp*Spacing/3                                           1.834
Centre Lateral area aft st0 m = (Lm/Lp)*Spacing                                          3.753


Wetted surface area        sq m =  ws* Spacing/3                                         7.432
Total surface area         sq m =  Ts* Spacing/3                                        12.430
Sinkage               kg per cm = (b1*Spacing/3)*10.25                                  61.423
Prismatic coefficient           =  v2/ (MaXa*L)                                          0.636
Block coefficient               =  v2/(L*maxb*maxd)                                      0.460
Water plane coefficient         =  b1/(30*maxb)                                          0.703
Midship area coefficient        =  maxa/(maxb*maxd)                                      0.723
Lateral plane coefficient       =  Lp/(30*maxd)                                          0.864

$ * * * * * * * * * * * * * * * * * * * * * * * * * * *
$ CALCULATE INTERMEDIATE RESULTS STABILITY
$ ENTER V.C.G. about DWL
VCG=0                                                                                    0.000
$ * * * * * * * * * * * * * * * * * * * * * * * * * * *

Ilf=((wlb0+wlb10)*12.5)+((wlb0.5+wlb9.5)*40.5)+((wlb1+wlb9)*24)+((wlb2+wlb8)*3(       130.905
Il5=(Ilf*(spacing^3))/3                                                                 18.676
WPA=b1*spacing/3                                                                         5.993
LCF=((Lf/b1)*spacing)-(spacing*5)                                                       -0.042
It1=((((wlb0*0.5)^3)+((wlb10*0.5)^3))*0.5)+((((wlb0.5*0.5)^3)+((wlb3*0.5)^3)+((wlb      2.634
Il=Il5-(WPA*(LCF^2))                                                                    18.665
It=It1*spacing*2/9                                                                       0.441
BMl=Il/v2                                                                               16.905
BMt=It/v2                                                                                0.399
KB=maxd+(vb/v1)                                                                          0.177
KG=maxd+VCG                                                                              0.282
GMl=KB+BMl-KG                                                                           16.801
GMt=KB+BMt-KG                                                                            0.295

$ CALCULATE RESULTS STABILITY DATA
$ * * * * * * * * * * * * * * * * * * * * * *
Longitudinal Inertia  about LCF          m4 =Il5-(WPA*(LCF^2))                          18.665
Transverse Inertia about centreline       m4  =(It1*spacing*2)/9                         0.441
BM longitudinal                            m =Il/v2                                     16.905
BM transverse                              m =It/v2                                      0.399
GM longitudinal                           m =KB+BMl-KG                                  16.801
GM transverse                              m =KB+BMt-KG                                  0.295
Moments to change trim 1 cm          kgm cm =((v2*1025)*GMl)/(100*L)                    25.230
Righting Moment at 1 degree              kgm =v2*1025*GMt*0.0175                         5.836
```

Hydrostatic Analysis of *houri* AH3

$ CALCULATE INTERMEDIATE RESULTS HYDROSTATICS
$ ....

v1=((sa0+sa10)*0.5)+((sa1+sa9)*1.5)+((sa0.5+sa3+sa5+sa7+sa9.5)*2)+((sa2+sa4+sa	2.186
v2=(v1*Spacing)/3	0.372
Lb=sa0.5+(sa1*1.5)+(sa2*8)+(sa3*6)+(sa4*16)+(sa5*10)+(sa6*24)+(sa7*14)+(sa8*3	10.837
b1=((wlb0+wlb10)*0.5)+((wlb1+wlb9)*1.5)+((wlb0.5+wlb3+wlb5+wlb7+wlb9.5)*2)+((v	19.442
Vb=(((sa0*cav0)+(sa10*cav10))*0.5)+(((sa1*cav1)+(sa9*cav9))*1.5)+(((sa0.5*cav0.	-0.136
ws=((igir0+igir10)*0.5)+((igir1+igir9)*1.5)+((igir0.5+igir3+igir5+igir7+igir9.5)*2)+((	22.334
ts=((tgir0+tgir10)*0.5)+((tgir1+tgir9)*1.5)+((tgir0.5+tgir3+tgir5+tgir7+tgir9.5)*2)+(	39.471
Lm=dr0.5+(dr1*1.5)+(dr2*8)+(dr3*6)+(dr4*16)+(dr5*10)+(dr6*24)+(dr7*14)+(dr8*	18.347
Lp=((dr0+dr10)*0.5)+((dr1+dr9)*1.5)+((dr0.5+dr3+dr5+dr7+dr9.5)*2)+((dr2+dr4+dr(	3.785
Lf=wlb0.5+(wlb1*1.5)+(wlb2*8)+(wlb3*6)+(wlb4*16)+(wlb5*10)+(wlb6*24)+(wlb7*1	98.525
L =spacing*10	5.101

$ CALCULATE FINAL VALUES HYDROSTATICS
$ ....

Length water line	m = L	5.101
Max cross section	sq m = maxa	0.124
Hull draught	m = maxd	0.150
Beam waterline	m = maxb	0.956
Displacement	kg = v2 * 1025	381.014
LCB aft of st0	m = (Lb/v1)*Spacing	2.529
LCB as percentage	= 10* (Lb/v1)	49.571
VCB below dwl	m = Vb/v1	-0.063
Waterplane area	sq m = b1*Spacing/3	3.306
LCF aft of st0	m = (Lf/b1)*Spacing	2.585
LCF as percentage	= 10*(Lf/b1)	50.677
Lateral plane area	sq m = Lp*Spacing/3	0.644
Centre Lateral area aft st0	m = (Lm/Lp)*Spacing	2.473
Wetted surface area	sq m = ws* Spacing/3	3.797
Total surface area	sq m = Ts* Spacing/3	6.711
Sinkage	kg per cm = (b1*Spacing/3)*10.25	33.883
Prismatic coefficient	= v2/ (MaXa*L)	0.586
Block coefficient	= v2/(L*maxb*maxd)	0.508
Water plane coefficient	= b1/(30*maxb)	0.678
Midship area coefficient	= maxa/(maxb*maxd)	0.867
Lateral plane coefficient	= Lp/(30*maxd)	0.841

$ ....
$ CALCULATE INTERMEDIATE RESULTS STABILITY
$ ENTER V.C.G. about DWL

VCG=0	0.000

$ ....

Ilf=((wlb0+wlb10)*12.5)+((wlb0.5+wlb9.5)*40.5)+((wlb1+wlb9)*24)+((wlb2+wlb8)*3(	102.610
Il5=(Ilf*(spacing^3))/3	4.540
WPA=b1*spacing/3	3.306
LCF=((Lf/b1)*spacing)-(spacing*5)	0.035
It1=((((wlb0*0.5)^3)+((wlb10*0.5)^3))*0.5)+((((wlb0.5*0.5)^3)+((wlb3*0.5)^3)+((wlb	1.496
Il=Il5-(WPA*(LCF^2))	4.536
It=It1*spacing*2/9	0.170
BMl=Il/v2	12.202
BMt=It/v2	0.456
KB=maxd+(vb/v1)	0.087
KG=maxd+VCG	0.150
GMl=KB+BMl-KG	12.139
GMt=KB+BMt-KG	0.393

$ CALCULATE RESULTS STABILITY DATA
$ ....

Longitudinal Inertia about LCF	m4 =Il5-(WPA*(LCF^2))	4.536
Transverse Inertia about centreline	m4 =(It1*spacing*2)/9	0.170
BM longitudinal	m =Il/v2	12.202
BM transverse	m =It/v2	0.456
GM longitudinal	m =KB+BMl-KG	12.139
GM transverse	m =KB+BMt-KG	0.393
Moments to change trim 1 cm	kgm cm =((v2*1025)*GMl)/(100*L)	9.067
Righting Moment at 1 degree	kgm =v2*1025*GMt*0.0175	2.622

Hydrostatic Analysis of *badan* AT8

```
$ CALCULATE INTERMEDIATE RESULTS HYDROSTATICS
$ ********************************
v1=((sa0+sa10)*0.5)+((sa1+sa9)*1.5)+((sa0.5+sa3+sa5+sa7+sa9.5)*2)+((sa2+sa4+sa        6.715
v2=(v1*Spacing)/3                                                                      2.084
Lb=sa0.5+(sa1*1.5)+(sa2*8)+(sa3*6)+(sa4*16)+(sa5*10)+(sa6*24)+(sa7*14)+(sa8*3.        34.439
b1=((wlb0+wlb10)*0.5)+((wlb1+wlb9)*1.5)+((wlb0.5+wlb3+wlb5+wlb7+wlb9.5)*2)+((v        30.627
Vb=(((sa0*cav0)+(sa10*cav10))*0.5)+(((sa1*cav1)+(sa9*cav9))*1.5)+(((sa0.5*cav0.       -0.894
ws=((iglr0+iglr10)*0.5)+((iglr1+igir9)*1.5)+((iglr0.5+iglr3+igir5+igir7+igir9.5)*2)+((    37.289
ts=((tglr0+tglr10)*0.5)+((tgir1+tgir9)*1.5)+((tglr0.5+tgir3+tgir5+tgir7+tgir9.5)*2)+(    73.992
Lm=dr0.5+(dr1*1.5)+(dr2*8)+(dr3*6)+(dr4*16)+(dr5*10)+(dr6*24)+(dr7*14)+(dr8*          40.702
Lp=((dr0+dr10)*0.5)+((dr1+dr9)*1.5)+((dr0.5+dr3+dr5+dr7+dr9.5)*2)+((dr2+dr4+dr(       8.689
Lf=wlb0.5+(wlb1*1.5)+(wlb2*8)+(wlb3*6)+(wlb4*16)+(wlb5*10)+(wlb6*24)+(wlb7*1        159.377
L  =spacing*10                                                                         9.310


Length water line          m = L                                                       9.310
Max cross section       sq m = maxa                                                    0.401
Hull draught               m = maxd                                                    0.343
Beam waterline             m = maxb                                                    1.704
Displacement              kg = v2 * 1025                                            2135.909

LCB aft of st0             m = (Lb/v1)*Spacing                                         4.775
LCB  as percentage           = 10* (Lb/v1)                                            51.288
VCB  below dwl             m = Vb/v1                                                  -0.133

Waterplane area         sq m = b1*Spacing/3                                            9.504
LCF aft of st0                 m = (Lf/b1)*Spacing                                     4.845
LCF as percentage            = 10*(Lf/b1)                                             52.038

Lateral plane area      sq m = Lp*Spacing/3                                            2.696
Centre Lateral area aft st0 m = (Lm/Lp)*Spacing                                        4.361


Wetted surface area     sq m =  ws* Spacing/3                                         11.572
Total surface area      sq m =  Ts* Spacing/3                                         22.962
Sinkage              kg per cm = (b1*Spacing/3)*10.25                                 97.420
Prismatic coefficient          = v2/ (MaXa*L)                                          0.558
Block coefficient                = v2/(L*maxb*maxd)                                    0.382
Water plane coefficient        = b1/(30*maxb)                                          0.599
Midship area coefficient       = maxa/(maxb*maxd)                                      0.685
Lateral plane coefficient      = Lp/(30*maxd)                                          0.843

$ ******************************
$ CALCULATE INTERMEDIATE RESULTS STABILITY
$ ENTER V.C.G. about DWL
VCG=0                                                                                  0.000
$ ******************************

Ilf=((wlb0+wlb10)*12.5)+((wlb0.5+wlb9.5)*40.5)+((wlb1+wlb9)*24)+((wlb2+wlb8)*3(     121.970
Il5=(Ilf*(spacing^3))/3                                                               32.807
WPA=b1*spacing/3                                                                       9.504
LCF=((Lf/b1)*spacing)-(spacing*5)                                                      0.190
It1=((((wlb0*0.5)^3)+((wlb10*0.5)^3))*0.5)+((((wlb0.5*0.5)^3)+((wlb3*0.5)^3)+((wlb     7.996
Il=Il5-(WPA*(LCF^2))                                                                  32.464
It=It1*spacing*2/9                                                                     1.654
BMl=Il/v2                                                                             15.579
BMt=It/v2                                                                              0.794
KB=maxd+(vb/v1)                                                                        0.210
KG=maxd+VCG                                                                            0.343
GMl=KB+BMl-KG                                                                         15.446
GMt=KB+BMt-KG                                                                          0.661

$ CALCULATE RESULTS STABILITY DATA
$ *************************
Longitudinal Inertia  about LCF           m4 =Il5-(WPA*(LCF^2))                       32.464
Transverse Inertia about centreline        m4 =(It1*spacing*2)/9                       1.654
BM longitudinal                            m =Il/v2                                   15.579
BM transverse                              m =It/v2                                    0.794
GM longitudinal                           m =KB+BMl-KG                                15.446
GM transverse                              m =KB+BMt-KG                                0.661
Moments to change trim 1 cm             kgm cm =((v2*1025)*GMl)/(100*L)               35.437
Righting Moment at 1 degree                kgm =v2*1025*GMt*0.0175                    24.694
```

Hydrostatic Analysis of *badan* KM1

```
$ CALCULATE INTERMEDIATE RESULTS HYDROSTATICS
$ ******************************
v1=((sa0+sa10)*0.5)+((sa1+sa9)*1.5)+((sa0.5+sa3+sa5+sa7+sa9.5)*2)+((sa2+sa4+sa      11.217
v2=(v1*Spacing)/3                                                                    4.301
Lb=sa0.5+(sa1*1.5)+(sa2*8)+(sa3*6)+(sa4*16)+(sa5*10)+(sa6*24)+(sa7*14)+(sa8*3.      55.765
b1=((wlb0+wlb10)*0.5)+((wlb1+wlb9)*1.5)+((wlb0.5+wlb3+wlb5+wlb7+wlb9.5)*2)+((v      38.936
Vb=(((sa0*cav0)+(sa10*cav10))*0.5)+(((sa1*cav1)+(sa9*cav9))*1.5)+(((sa0.5*cav0.     -1.902
ws=((igir0+igir10)*0.5)+((igir1+igir9)*1.5)+((igir0.5+igir3+igir5+igir7+igir9.5)*2)+((   48.521
ts=((tgir0+tgir10)*0.5)+((tgir1+tgir9)*1.5)+((tgir0.5+tgir3+tgir5+tgir7+tgir9.5)*2)+(   84.385
Lm=dr0.5+(dr1*1.5)+(dr2*8)+(dr3*6)+(dr4*16)+(dr5*10)+(dr6*24)+(dr7*14)+(dr8*        56.422
Lp=((dr0+dr10)*0.5)+((dr1+dr9)*1.5)+((dr0.5+dr3+dr5+dr7+dr9.5)*2)+((dr2+dr4+dr(      12.014
Lf=wlb0.5+(wlb1*1.5)+(wlb2*8)+(wlb3*6)+(wlb4*16)+(wlb5*10)+(wlb6*24)+(wlb7*1       196.212
L  =spacing*10                                                                      11.503
```

Length water line	m = L	11.503
Max cross section	sq m = maxa	0.660
Hull draught	m = maxd	0.444
Beam waterline	m = maxb	2.160
Displacement	kg = v2 * 1025	4408.633
LCB aft of st0	m = (Lb/v1)*Spacing	5.719
LCB as percentage	= 10* (Lb/v1)	49.714
VCB below dwl	m = Vb/v1	-0.170
Waterplane area	sq m = b1*Spacing/3	14.930
LCF aft of st0	m = (Lf/b1)*Spacing	5.797
LCF as percentage	= 10*(Lf/b1)	50.394
Lateral plane area	sq m = Lp*Spacing/3	4.607
Centre Lateral area aft st0	m = (Lm/Lp)*Spacing	5.403
Wetted surface area	sq m = ws* Spacing/3	18.605
Total surface area	sq m = Ts* Spacing/3	32.357
Sinkage	kg per cm = (b1*Spacing/3)*10.25	153.030
Prismatic coefficient	= v2/ (MaXa*L)	0.566
Block coefficient	= v2/(L*maxb*maxd)	0.390
Water plane coefficient	= b1/(30*maxb)	0.601
Midship area coefficient	= maxa/(maxb*maxd)	0.689
Lateral plane coefficient	= Lp/(30*maxd)	0.902

```
$ ******************************
$ CALCULATE INTERMEDIATE RESULTS STABILITY
$ ENTER V.C.G. about DWL
VCG=0                                                                                0.000
$ ******************************

Ilf=((wlb0+wlb10)*12.5)+((wlb0.5+wlb9.5)*40.5)+((wlb1+wlb9)*24)+((wlb2+wlb8)*3(    155.982
Il5=(Ilf*(spacing^3))/3                                                             79.144
WPA=b1*spacing/3                                                                    14.930
LCF=((Lf/b1)*spacing)-(spacing*5)                                                    0.045
It1=((((wlb0*0.5)^3)+((wlb10*0.5)^3))*0.5)+((((wlb0.5*0.5)^3)+((wlb3*0.5)^3)+((wlb   15.985
Il=Il5-(WPA*(LCF^2))                                                                79.113
It=It1*spacing*2/9                                                                   4.086
BMl=Il/v2                                                                           18.394
BMt=It/v2                                                                            0.950
KB=maxd+(vb/v1)                                                                      0.274
KG=maxd+VCG                                                                          0.444
GMl=KB+BMl-KG                                                                       18.224
GMt=KB+BMt-KG                                                                        0.780

$ CALCULATE RESULTS STABILITY DATA
$ *************************
```

Longitudinal Inertia about LCF	m4 =Il5-(WPA*(LCF^2))	79.113
Transverse Inertia about centreline	m4 =(It1*spacing*2)/9	4.086
BM longitudinal	m =Il/v2	18.394
BM transverse	m =It/v2	0.950
GM longitudinal	m =KB+BMl-KG	18.224
GM transverse	m =KB+BMt-KG	0.780
Moments to change trim 1 cm	kgm cm =((v2*1025)*GMl)/(100*L)	69.844
Righting Moment at 1 degree	kgm =v2*1025*GMt*0.0175	60.211

Hydrostatic Analysis of *battil* KO2

```
$ CALCULATE INTERMEDIATE RESULTS HYDROSTATICS
$ ********************************
v1=((sa0+sa10)*0.5)+((sa1+sa9)*1.5)+((sa0.5+sa3+sa5+sa7+sa9.5)*2)+((sa2+sa4+sa      9.060
v2=(v1*Spacing)/3                                                                   2.476
Lb=sa0.5+(sa1*1.5)+(sa2*8)+(sa3*6)+(sa4*16)+(sa5*10)+(sa6*24)+(sa7*14)+(sa8*3.     51.401
b1=((wlb0+wlb10)*0.5)+((wlb1+wlb9)*1.5)+((wlb0.5+wlb3+wlb5+wlb7+wlb9.5)*2)+((v    33.680
Vb=(((sa0*cav0)+(sa10*cav10))*0.5)+(((sa1*cav1)+(sa9*cav9))*1.5)+(((sa0.5*cav0.    -1.587
ws=((igir0+igir10)*0.5)+((igir1+igir9)*1.5)+((igir0.5+igir3+igir5+igir7+igir9.5)*2)+((   49.041
ts=((tgir0+tgir10)*0.5)+((tgir1+tgir9)*1.5)+((tgir0.5+tgir3+tgir5+tgir7+tgir9.5)*2)+(   98.553
Lm=dr0.5+(dr1*1.5)+(dr2*8)+(dr3*6)+(dr4*16)+(dr5*10)+(dr6*24)+(dr7*14)+(dr8*      74.035
Lp=((dr0+dr10)*0.5)+((dr1+dr9)*1.5)+((dr0.5+dr3+dr5+dr7+dr9.5)*2)+((dr2+dr4+dr(   15.106
Lf=wlb0.5+(wlb1*1.5)+(wlb2*8)+(wlb3*6)+(wlb4*16)+(wlb5*10)+(wlb6*24)+(wlb7*1     191.916
L  =spacing*10                                                                      8.198
```

Length water line	m = L	8.198
Max cross section	sq m = maxa	0.601
Hull draught	m = maxd	0.645
Beam waterline	m = maxb	1.932
Displacement	kg = v2 * 1025	2537.940
LCB aft of st0	m = (Lb/v1)*Spacing	4.651
LCB as percentage	= 10* (Lb/v1)	56.732
VCB below dwl	m = Vb/v1	-0.175
Waterplane area	sq m = b1*Spacing/3	9.204
LCF aft of st0	m = (Lf/b1)*Spacing	4.672
LCF as percentage	= 10*(Lf/b1)	56.983
Lateral plane area	sq m = Lp*Spacing/3	4.128
Centre Lateral area aft st0	m = (Lm/Lp)*Spacing	4.018
Wetted surface area	sq m = ws* Spacing/3	13.402
Total surface area	sq m = Ts* Spacing/3	26.933
Sinkage	kg per cm = (b1*Spacing/3)*10.25	94.342
Prismatic coefficient	= v2/ (MaXa*L)	0.503
Block coefficient	= v2/(L*maxb*maxd)	0.242
Water plane coefficient	= b1/(30*maxb)	0.581
Midship area coefficient	= maxa/(maxb*maxd)	0.482
Lateral plane coefficient	= Lp/(30*maxd)	0.780

```
$ ******************************
$ CALCULATE INTERMEDIATE RESULTS STABILITY
$ ENTER V.C.G. about DWL
VCG=0                                                                               0.000
$ ******************************

Ilf=((wlb0+wlb10)*12.5)+((wlb0.5+wlb9.5)*40.5)+((wlb1+wlb9)*24)+((wlb2+wlb8)*3(   149.969
Il5=(Ilf*(spacing^3))/3                                                            27.547
WPA=b1*spacing/3                                                                    9.204
LCF=((Lf/b1)*spacing)-(spacing*5)                                                   0.572
It1=((((wlb0*0.5)^3)+((wlb10*0.5)^3))*0.5)+((((wlb0.5*0.5)^3)+((wlb3*0.5)^3)+((wlb   10.704
Il=Il5-(WPA*(LCF^2))                                                               24.531
It=It1*spacing*2/9                                                                  1.950
BMl=Il/v2                                                                           9.907
BMt=It/v2                                                                           0.788
KB=maxd+(vb/v1)                                                                     0.470
KG=maxd+VCG                                                                         0.645
GMl=KB+BMl-KG                                                                       9.732
GMt=KB+BMt-KG                                                                       0.612

$ CALCULATE RESULTS STABILITY DATA
$ **************************
```

Longitudinal Inertia about LCF	m4 =Il5-(WPA*(LCF^2))	24.531
Transverse Inertia about centreline	m4 =(It1*spacing*2)/9	1.950
BM longitudinal	m =Il/v2	9.907
BM transverse	m =It/v2	0.788
GM longitudinal	m =KB+BMl-KG	9.732
GM transverse	m =KB+BMt-KG	0.612
Moments to change trim 1 cm	kgm cm =((v2*1025)*GMl)/(100*L)	30.127
Righting Moment at 1 degree	kgm =v2*1025*GMt*0.0175	27.200

Hydrostatic Analysis of sewn *sambuq* EX1

```
$ CALCULATE INTERMEDIATE RESULTS HYDROSTATICS
$ * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
v1=((sa0+sa10)*0.5)+((sa1+sa9)*1.5)+((sa0.5+sa3+sa5+sa7+sa9.5)*2)+((sa2+sa4+sa        4.644
v2=(v1*Spacing)/3                                                                      1.047
Lb=sa0.5+(sa1*1.5)+(sa2*8)+(sa3*6)+(sa4*16)+(sa5*10)+(sa6*24)+(sa7*14)+(sa8*3        23.908
b1=((wlb0+wlb10)*0.5)+((wlb1+wlb9)*1.5)+((wlb0.5+wlb3+wlb5+wlb7+wlb9.5)*2)+((w      21.424
Vb=(((sa0*cav0)+(sa10*cav10))*0.5)+(((sa1*cav1)+(sa9*cav9))*1.5)+(((sa0.5*cav0.      -0.618
ws=((lglr0+lglr10)*0.5)+((lglr1+lglr9)*1.5)+((lglr0.5+lglr3+lglr5+lglr7+lglr9.5)*2)+((l   37.231
ts=((tglr0+tglr10)*0.5)+((tglr1+tglr9)*1.5)+((tglr0.5+tglr3+tglr5+tglr7+tglr9.5)*2)+(    73.103
Lm=dr0.5+(dr1*1.5)+(dr2*8)+(dr3*6)+(dr4*16)+(dr5*10)+(dr6*24)+(dr7*14)+(dr8*         65.046
Lp=((dr0+dr10)*0.5)+((dr1+dr9)*1.5)+((dr0.5+dr3+dr5+dr7+dr9.5)*2)+((dr2+dr4+dr       12.610
Lf=wlb0.5+(wlb1*1.5)+(wlb2*8)+(wlb3*6)+(wlb4*16)+(wlb5*10)+(wlb6*24)+(wlb7*1        110.100
L  =spacing*10                                                                         6.763

$ CALCULATE FINAL VALUES HYDROSTATICS
$ * * * * * * * * * * * * * * * * * * * * * * * * * * *
Length water line          m = L                                                       6.763
Max cross section       sq m = maxa                                                    0.324
Hull draught               m = maxd                                                    0.450
Beam waterline             m = maxb                                                    1.260
Displacement              kg =  v2 * 1025                                           1073.129

LCB aft of st0             m = (Lb/v1)*Spacing                                         3.481
LCB  as percentage           = 10* (Lb/v1)                                            51.478
VCB  below dwl             m = Vb/v1                                                  -0.133

Waterplane area         sq m = b1*Spacing/3                                            4.830
LCF aft of st0               m = (Lf/b1)*Spacing                                       3.475
LCF as percentage            = 10*(Lf/b1)                                             51.391

Lateral plane area      sq m = Lp*Spacing/3                                            2.843
Centre Lateral area aft st0 m = (Lm/Lp)*Spacing                                        3.488


Wetted surface area     sq m =  ws* Spacing/3                                          8.393
Total surface area      sq m =  Ts* Spacing/3                                         16.479
Sinkage               kg per cm = (b1*Spacing/3)*10.25                                49.503
Prismatic coefficient        = v2/ (MaXa*L)                                            0.477
Block coefficient            =  v2/(L*maxb*maxd)                                       0.273
Water plane coefficient      =  b1/(30*maxb)                                           0.567
Midship area coefficient     =  maxa/(maxb*maxd)                                       0.572
Lateral plane coefficient    = Lp/(30*maxd)                                            0.934

$ * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
$ CALCULATE INTERMEDIATE RESULTS STABILITY
$ ENTER V.C.G. about DWL
VCG=0                                                                                  0.000
$ * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

Ilf=((wlb0+wlb10)*12.5)+((wlb0.5+wlb9.5)*40.5)+((wlb1+wlb9)*24)+((wlb2+wlb8)*36     87.685
Il5=(Ilf*(spacing^3))/3                                                                9.040
WPA=b1*spacing/3                                                                       4.830
LCF=((Lf/b1)*spacing)-(specing*5)                                                      0.094
It1=((((wlb0*0.5)^3)+((wlb10*0.5)^3))*0.5)+((((wlb0.5*0.5)^3)+((wlb3*0.5)^3)+((wlb     2.726
Il=Il5-(WPA*(LCF^2))                                                                   8.998
It=It1*spacing*2/9                                                                     0.410
BMl=Il/v2                                                                              8.594
BMt=It/v2                                                                              0.391
KB=maxd+(vb/v1)                                                                        0.317
KG=maxd+VCG                                                                            0.450
GMl=KB+BMl-KG                                                                          8.461
GMt=KB+BMt-KG                                                                          0.258

$ CALCULATE RESULTS STABILITY DATA
$ * * * * * * * * * * * * * * * * * * * * * * * * *
Longitudinal Inertia  about LCF             m4 =Il5-(WPA*(LCF^2))                      8.998
Transverse Inertia about centreline         m4 =(It1*spacing*2)/9                      0.410
BM longitudinal                              m =Il/v2                                  8.594
BM transverse                                m =It/v2                                  0.391
GM longitudinal                              m =KB+BMl-KG                              8.461
GM transverse                                m =KB+BMt-KG                              0.258
Moments to change trim 1 cm            kgm cm =((v2*1025)*GMl)/(100*L)                13.426
Righting Moment at 1 degree                kgm =v2*1025*GMt*0.0175                     4.849
```

APPENDIX D
Sample Analyses

List of samples

NUMBER	DATE	SOURCE	Material	DESCRIPTION
1	11/25/92	AH2	Caulking	Caulking of cotton and shark oil.
2	11/26/92	AH1	Fastening, copper	Copper fastening (rivet and rove)
3	11/26/92	AH1	Wood	Wood sample
4	11/26/92	AH3	Wood	Wood sample of frame from houri
5	11/27/92	AH10	Wood	Wood sample from the bow
6	11/27/92	AH13	Luting	Luting sample from damaged stern
7	11/27/92	M2	Caulking	Caulking sample from stern of planked houri at Maraq
8	11/27/92	BA1	Wood	Wood sample from sternpost of planked houri (Barka)
9	11/27/92	BA1	Wood	Wood sample from frame of planked houri (Barka)
10	11/30/92	KM1	Wood	Wood sample from stbd futtock of frame station 33 of badan
11	12/1/92	KM1	Fastening, iron	Iron nail found loose of foredeck
12	12/2/92	MA7	Wood	Oblique dowel from badan stern fragment
13	12/2/92	MA7	Wood	Horizontal dowels (3) from badan stern fragment
14	12/2/92	MA7	Wood	Wood samples (2) from badan stern fragment
15	12/2/92	MA7	Wood	Wood samples (2) from badan stern fragment
16	12/2/92	MA7	Wood	Piece of thole pin cleat from badan stern fragment
17	12/2/92	MA7	Wood	Wood sample from plank from badan stern fragment
18	12/2/92	MA7	Wood	Wood sample from lower fin cheek of badan stern fragment
19	12/2/92	MA7	Wood	Wood sample from fin from badan stern fragment
20	12/2/92	MA7	Wood	Wood sample from deck of badan stern fragment
21	12/2/92	MA7	Wood	Wood sample from tail fin brace from badan stern fragment
22	12/2/92	MA7	Wood	Wood sample from plank of badan stern fragment
23	12/2/92	MA7	Wood	Wood sample from caprail of badan stern fragment
24	12/2/92	MA8	Fastening, iron	Nail from planked houri
25	12/2/92	MA8	Wood	Horizontal dowels from planked houri
26	12/2/92	MA8	Wood	Wood sample from beam shelf of planked houri
27	12/2/92	MA8	Wood	Wood sample from planked houri
28	12/2/92	SH1	Fastening, iron	Nail from deck of baggarah (shahouf?) buried in sand at Shinas
29	12/2/92	SH1	Wood	Dowels from baggarah
30	12/2/92	tree	Wood	Sample twig from tree used to make frame timbers, Shinas
31	12/6/92	AT8	Fastening, iron	Loose nail found in sand near badan (Athaibah)
32	12/6/92	AT8	Fastening, iron	Head and part of shank of nail from aft deck
33	12/6/92	AT8	Caulking	Caulking from exterior face of seam at port bow
34	12/6/92	AT8	Rope	Lacing rope from stem of badan
35	12/6/92	AT8	Wadding	Wadding used under the lacing at the stem (port side)
36	12/6/92	AT17	Wood	Wood sample of the tail fin of badan
37	12/6/92	AT17	Wood	Wood sample of beam
38	7/12/92?	AT10	Putty	Caulking putty from aft face of hood ends
39	12/10/92	SU1	Wood	Wood from forward port inwale of fishing shu'i, Sur
40	12/11/92	AS1	Wood	Floor timber from large badan, Al Ashkharah
41	12/11/92	AS1	Wood	Cap rail
42	12/11/92	AS1	Wood	Deck Plank
43	12/11/92	AS1	Wood	Inwale
44	12/12/92	Sur1	Wood	Large trunk
45	12/12/92	Sur2	Wood	Frame timber
46	12/12/92	Sur3	Wood	??
47	12/12/92	Sur4	Wood	Upper inwale—red timber
48	12/12/92	Sur5	Wood	Frame timber?
49	12/12/92	Sur6	Wood	Keel
50	12/12/92	Sur7	Wood	Stem post
51	12/12/92	Sur8	Wood	Horn timber
52	12/15/92	KO2	Resin	Substance from metal bowl aboard KO2
53	12/15/92	KO2	Resin	Substance scraped from inside of planking
54	12/15/92	KO2	Resin	Substance scraped from cloth (drop cloth?) aboard KO2
55	12/17/92	Atheiba	Wood	Sample from scrap of dugout hull

Wood Samples

Thirty-nine samples of timber were made from various vessels and boat building yards. These were obtained only with owners permission, or in eases where the timber was already broken or cut.

Sample preparation

The samples were prepared in small (average 12-15 mm) blocks cut and polished on their radial, transverse and tangential surfaces. The samples were then examined with a hand lens and with an Olympus SZ4045TR stereo optic microscope. The wood samples were identified by inspection and recognition of macro features, such as pore size, numbers and distribution, ray cell characteristics, growth ring patterns, soft tissue distribution and the presence or absence of oils cells and tyloses (see below for complete list). The recognised features of each sample were fed into the computer-based wood identification program of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), which then searched its databank of timber species for any species exhibiting the selected features. Some samples were too small, or in such poor condition as to preclude positive recognition of some features.

The processes of sample preparation, examination and feature identification are naturally tedious and time consuming. Hence, these processes continue, with the aim of identifying all the samples.

Of the samples identified, one notes *Dipterocarpus* species recurring with some frequency. It is well known that much of the boat building timber used in the Sultanate is imported from India. As *Dipterocarpus* species are commonly used in boat building and found in India, their appearance in the samples, though informative, is not a surprise. One of the finest boat building timbers in the world, teak (*Tectona grandis*), also appears frequently in the samples. This too is common in India (though no longer exported in an unworked state—teak now being used in Sur is imported from Malaysia) and was well known as the preferred planking timber for Omani vessels. It was somewhat of a surprise to find it used for dowels (*baggarah* SH1 at Shinas). However, its use as a dowel was for the purpose of plugging disused holes, not for edge-joining planks, where a harder, tougher timber would have been more suitable. It the case of plugging holes, *Tectona grandis* is probably quite suitable and tends to confirm the fact that Omani boat builders are knowledgeable about the proper use of specific species. As so much of the timber used in boats (particularly the dugouts) was popularly thought to be mango (*Mangifera* spp.) it was surprising that in the identifications so far done, no *Mangifera* spp. occur. It is thought that personnel from the Natural History Museum attached to the Ministry of National Heritage and Culture in Oman might be able to suggest species of timber commonly used in the Sultanate, whether indigenous or imported, and thereby assist in identification of additional species.

Table of Features

COLOUR

No.	**Feature**
1.	Whitish, pale brown or yellow, straw
2.	Dark brown, definite brown
3.	Pink or red tints
4.	Other colours, e.g. black, purple, orange
5.	Streaky

RAYS

6.	Of two distinct widths

7. As wide as or wider than pores
8. Narrower than pores
9. Markedly heterogeneous
10. High and conspicuous on radial surface
11. With gum canals

SOFT TISSUE

12. Absent
13. In regular bands wider than pores
14. In regular bands narrower than pores
15. In irregularly spaced bands
16. Surrounding pores
17. Wing-like, confluent
18. Diffuse
19. Diffuse in aggregate

OTHER FEATURES

20. A definite odour
21. Growth rings distinct
22. Ripple marks
23. Vertical canals present
24. Distinct oiliness or greasiness
25. Splinters burn to charcoal

TOPOGRAPHY

26-29. Not applicable

LOCALITY

30-35. Not applicable

PORE NUMBER

36. Few (4 or less per sq mm)
37. Moderately numerous (5-11 per sq mm)
38. Very numerous (12 or more per sq mm)

PORE SIZE

39. Large (distinct to naked eye)
40. Intermediate (visible without strain)
41. Small (indistinct to naked eye)
42. Very small (indistinct even with lens)

PORE ARRANGEMENT

43. Absent
44. Ring-porous or semi-ring-porous
45. Predominantly solitary
46. Radial multiples up to 4
47. Radial multiples over 4
48. Oblique, flares
49. Tangential
50. Clusters
51. Tyloses abundant
52. White or yellow deposits present

WEIGHT

53-56. Not applicable due to small sample size

OTHER FEATURES

57. Crystals visible
58. Multiple perforation plates
59. Oil cells
60. Anomalous tissue

STRENGTH GROUPS AND DURABILITY

61-73. Not applicable

Wood Identification

Below are listed the samples with positive or tentative identifications. Where only one species is listed the identification is believed solid. Under the column headed 'Features recognised' those features clearly evident in the sample are marked in bold type. Where the presence of other features is thought likely but not certain, the feature number is given in normal type face. In some instances, the features recognised eliminated all possible species in the database, probably indicating a need to expand the database to include more timbers common to the Middle East..

No.	Source	Features recognised	Identification
10	Futtock, *badan* KM1	**8,15,17,37,41,45,** 46, 48	*Balanocarpus* spp., *Hopea acuminatissima* with 48, *Hopea plagata*
13	Treenail, *badan* MA7	**8,13,37,41,44,45,51,** 59	*Dipterocarpus* spp.
14	Frame, MA7	**8,18,37,41,45,46**	*Dipterocarpus* spp.
15	Sternpost, *badan* MA7	7, **8,**12,16,18,**36,**41,42, **45,48,51**	*Castanopsis acuminatissima* *Calophyllum inophyllum* *Dipterocarpus* spp.
17	Planking, *badan* MA7	**8,16,21,37,40,44, 45,46,51**	*Tectona grandis*
18	Lower cheek knee, MA7	**8,** 10, **16, 37,40, 41, 45, 48, 52,** 57	*Dipterocarpus* spp.
19	Stern fin, *badan* MA7	**8,14,16,17,39,45,51**	probably *Dipterocarpus* spp. or *Anisoptera* spp.
20	Deck, *badan* MA7	**8,10,12,**16,**37,41,45,52**	*Syncarpia hillii*
21	Stern fin brace, MA7	**2,8,16,37,39,40,51,52**	*Tectona grandis*
22	Planking, *badan* MA7	**8,** 12,13,15,**16,21,37 45,46, 51,52**	*Tectona grandis*
25	Treenail, MA8	**8, 13,21,37,40,41,44 45,51**	0 species remaining in database

26	Beam shelf, MA8	**8,19,36,37,40,45,45**	with 37, *Bankhousia bancroftii* *Castanopsis acuminatissima,* *Dipterocarpus* spp., *Tarrietia (Herietera) simplicifolia*
27	Caprail, MA7	**8,16,18,38,**40**,41,45, 46,**48,51,**52**	*Neonauclea* spp. (with 48) *Vatica acrocarpa* (with 51) *Vatica mangachapoi* (with 51) *Vatica oblongfolia* (with 40) *Vatica papuana*
29	Dowel, SH1	**2,8,16,37,39,40,44,51,52**	*Tectona grandis*
37	Beam, AT17	**8,**15**,16,17,37,40,45, 46,**48**,52**	*Anisoptera kostermansiana* *Anisoptera costata* (both with 15) *Dipterocarpus exalatus* (with 48)
40	Floor timber, AS2	**8,16,36,39,45,46,**48	*Dipterocarpus* spp. *Pentacme contorta*
41	Caprail, AS2	**8,15,17,36,39,**40,**45,46, 48**	*Pentacme contorta*
42	Deck, AS2		So far unidentified softwood
43	Inwale, AS2	**8,15,16,17,19,36,40,45,52**	0 species remaining in database
55	Dugout, Al Atheiba	**8,**12,**16,22,36,39,45,**	*Tarrietia (Heretiera) simplicifolia*

Resin samples

Four samples of resinous materials were collected and analysed. All samples were extracted with dichloromethane, the extracts filtered and then concentrated by evaporation to leave the organic component of the extract. Four samples of resinous material were analysed by NMR (Nuclear Magnetic Resonance) spectroscopy at the University of Western Australia, in collaboration with Professor Emil Ghisalberti. Samples of the unextracted crude materials were also forwarded to the Chemistry Centre of Western Australia for further analysis.

Sample No. 53, scraped from inside of the planking of *battil* KO2:
After extraction there was a substantial amount of insoluble residue. This was made up of what appeared to be sand/dirt and other fine-grained material. Extract was a deep brown oil (0.243 g).

Sample No. 52, taken from a bowl aboard KO2
Insoluble residues were as for the previous sample. The extract was a deep brown oil (0.254 g).

Sample No. 54, scraped from a woven plastic (polypropylene) cloth aboard KO2

Following extraction there was no insoluble residue except for two large lumps that looked like shell fragments. Extract was a deep brown oil with a strong bituminous odour (0.262 g)

Sample No. 6, taken from luting on AH13
The organic component dissolved readily but left a substantial quantity of insoluble material behind.

Nuclear Magnetic Resonance (NMR) spectroscopy analysis:

> The organic components of samples 52, 53 and 6 are almost pure fatty material (triglycerides and hydrolysed material) with low degrees of unsaturation. As such the likely source of such materials is animal fat.
>
> Sample 52 appears to be almost pure unhydrolysed fat (triglycerides) Sample 53 is a mixture of both hydrolysed and unhydrolysed fatty material while Sample 6 is predominantly hydrolysed fatty material (fatty acids).
>
> Sample 53 is a mixture of materials, comprising mainly hydrolysed fatty material (similar to Sample 6) and another component, most probably a plant resin. Further fractionation will be necessary to unambiguously identify the components of this mixture.
>
> These results are consistent with the provenance of the samples—those that were in use and exposed to weathering elements (Samples 52, 53 and 6) show a higher degree of hydrolysis than the less exposed material (Sample 54).

Combined Fourier Transform infra-red (FT-IR) spectroscopic and pyrolysis gas chromotographic (py gc) analyses:

> These analyses found that all samples contained long chain fatty acids from C-4 to C-18, with C-16 (palmitic acid) being the most abundant. The acids were found to present as free acids and not as triglycerides or waxes. This latter finding is contrary to the NMR evidence where the presence of mixtures of hydrolysed (free fatty acids) and unhydrolysed (triglycerides) fatty material was indicated. The NMR data is considered to be more reliable, as the conditions of extraction and analysis are less likely to have caused any change in the nature of the materials being analysed. It is likely under the pyrolysis conditions, cleavage of the triglycerides will have occurred, resulting in detection of the component fatty acids rather than the triglycerides themselves. Overlap of the acid and ester carbonyl absorptions did not allow for any differentiation of the free acids and the triglycerides in the IR spectra.
>
> In addition to the organic materials that were detected, Sample 6 also appeared to contain some calcium carbonate.

Conclusions
The pattern of fatty acid distribution (py gc) and the extent of saturation (NMR) indicate that the samples were likely to be derived from the fats of ruminant animals such as cows, sheep or goats. The presence of palmitic acid, which is present in high percentages in palm oil and lard from pigs is thought likely to derive in the samples from the former, due to local religious prohibitions about pork products.

APPENDIX E

Scantling Lists

Listed are the scantlings of all vessels that were documented in detail. They appear in alphabetical order, according to their coded designation.

AH1, *houri*, Al Haradi

Sides	thickness: 22-25	
Wash strake	thickness: 20	
Sculpted floors	width: 125-130	
Riders	width: 45	thickness: 30
Cross beam (bow)	sided: 65	moulded: 38
Bow	thickness: 30 tapering to 25 at the bottom	
Stern	thickness: 40 tapering to 25 at the bottom	
Hawse hole	diameter: 40	

AH3, *houri*, Al Haradi

Depth of hold: 520 (max)

Samples: #4, frame timber.

Scantling list (all measurements in mm)

Stringers (aft star)	width: 33	thickness: 20-25	
(aft port)	width: 40	thickness: 21	
(fore star)	width: 17	thickness: 19	
(fore port)	width: 27	thickness: 26	
Wales	sided: 20		moulded: 25
Stealer strakes	length: 3020 (star.), 3030 (port)		maximum width: 85
Limber holes	sided: 30 at the bottom, 20 at the top		moulded: 20

KM1, *badan*, Khawr Malah

Length: 13550

Maximum beam: 2390 (2475 with the wales)

Scantling list (all measurements in mm)

Stem	fore-and-aft: 135	athwartships: 37	
Apron	fore-and-aft: 140	athwartships: 70 (fore), 150 (aft)	
Sternpost	fore-and-aft: 90	athwartships: 75	
Frames	sided: 65-115	moulded: 45-75	(average, considerable variation)
	spacing (centre-to-centre): 270-280		
Caprails	sided: 45	moulded: 22	
	thole pin openings: 40x40	rectangular openings: 50x30	
Stringers	thickness: 22	width: 145	
Mast beam shelf	sided: 45	moulded: 70	length: 1080 (port), 1100 (star)
Wales	sided: 30	moulded: 50	
Mast beam, forward	sided: 160-120	moulded: 90	
after	sided: 90	moulded: 60	
Mast carlings	diameter: 45 (approx)	lengths: 950 (port), 960 (starboard)	
Main beam (foredeck)	sided: 75-90	moulded: 95	

	rabbet: 45 sided, 30 moulded	
Capping (foredeck)	sided: 45	moulded: 22
Main beam (aft deck)	sided: 65	moulded: 90
	rabbet: 25 sided, 30 moulded	
Beam (after part of hold)	sided: 77	moulded: 45
Thwart (at forward edge of foredeck)	sided: 230	moulded: 60
Beak cheek knees (lower)	sided: 40	moulded: 60
Top strake thickness: 25		
Deck plank thickness: 15-20		
Beak plank thickness: 32		
Thole pin cleat	sided: 85	moulded: 25

KO1, a *mashua*, Khawr Kumzar

Keel	sided: 70	moulded: 123 (forward), 110 (amidships), 88 (aft)
Stem	sided: 72	moulded: 120-135
Half-frame (stn #21)	sided: 63	moulded: 37
Floor (stn # 20)	sided: 55	moulded: 51
Caprail	sided: 187, tapers to 104 (stern) and 160 (bow)	moulded: 22
(starboard midship pieces)	sided: 164	moulded: 45
Wale (starboard)	sided: 34	moulded: 43
(port)	sided: 35	moulded: 40
Stringer	thickness: 22	width: 100
Main beam (aft deck)	sided: 63	moulded: 110
Capping (aft deck)	sided: 29	moulded: 22
Beam #2 (aft deck)	sided: 63	moulded: 61
Beams # 3 amd 4 are similar to #2		
Beam #5 (aft deck)	sided: 70	moulded: 49
Main beam (foredeck)	sided: 63	moulded: 89
Beam #2 (foredeck)	sided: 48	moulded: 63
Mast beam (forward)	sided: 140	moulded: 68
mast notch (semi-circular)		75 athwartships, 24 fore-and-aft
Mast beam (after)	sided: 146	moulded: 64
Carlings (between mast beams)	sided: 33	moulded: 23
Bulkhead stanchion (forward starboard)		50 athwartships, 34 fore-and-aft
(forward port)		43 athwartships, 35 fore-and-aft
(aft centre)		50-37 athwartships (tapers), 35 fore-and-aft
Stretcher (after)		sided: 57 moulded: 51
forward notch		47 athwartships, 54 fore-and-aft, 18 deep
after notch		38 athwartships, 25 fore-and-aft, 28 deep
Stretcher (forward)		sided: 49 moulded: 33
forward notch		39 athwartships, 31 fore-and-aft, 35 deep
after notch		52 athwartships, 31 fore-and-aft, 21 deep
Fin planking	thickness: 20	
Bulkhead planking	thickness: 20, width: 153 (average)	

Oars (4)	handle length: 2965-3680	handle width: 67-75	blade width: 146-161
	blade length: 1490 (max)	distance pull-fulcrum: 1258-1510	

KO2, *battil*, Khawr Kumzar

Keel sided: 85, tapering to 29 moulded: 125 (stern), 150 (midship), 95 (bow)
Stem sided: 25 moulded: 174 (approx)
Stern inpost height: 485 fore-and-aft: 65 athwartship: 120 (aft), 140 (fore)
Floors (bow) sided: 63 moulded: 43 (107 at the throat)
(midsh) sided: 66 moulded: 63 (136 at the throat)
(stern) sided: 53 moulded: 65 (122 at the throat)
Half-frames (bow) sided: 35 moulded: 47
(midship) sided: 67 moulded: 51
(stern) sided: 69 moulded: 56
Caprail starboard width: 132 (bow), 161 (midship), 175 (stern)
thickness: 32 (bow), 30 (midship), 27 (stern)
port width: 132 (bow), 176 (midship), 153 (stern)
thickness: 26 (bow), 37 (midship), 28 (stern)
(along stern rise, width: 139, thickness: 24, both approximately)
Stringer starboard width: 122 thickness: 18
port width: 123 thickness: 17
Inwales width: 102 thickness: 20
Main beam (aft deck) sided: 57 (max), 23 (min) + rabbet? moulded: 159
camber: 122
rabbet sided: 27-40 moulded: 25 (amidships)
2nd beam (aft deck) sided: 123 moulded: 99 (plus 62 for additional piece)
3rd beam (aft deck) sided: 79 moulded: 98
4th beam (aft deck) sided: 76 moulded: 82
5th beam (aft deck) sided: 54 moulded: 73
6th beam (aft deck) sided: 54 moulded: 72
7th beam (aft deck) sided: 39 moulded: 71
1st forward through-beam sided: 104 moulded: 38
camber: 92
2nd forward through-beam sided: 101 moulded: 48
Carling (between thetwo above beams) sided: 32 moulded: 28
Foredeck beam shelves (carlings) sided: 75 moulded: 68
Mast beam, forward sided: 163 moulded: 54
camber: 178 (approximately)
mast notch diameter: 116
Mast beam, after sided: 203 moulded: 34
camber: 182
Carlings (between mast beams) sided: 35 moulded: 28
Bulkhead stanchions athwartship: 45-55 fore-and-aft: 40-47
Stretcher, forward sided: 59 moulded: 64
after socket athwartship: 45 fore-and-aft: 26 depth: 16
forward notch athwartship: 49 fore-and-aft: 33 depth: 17
Stretcher, port aft sided: 81 moulded: 69
forward notch athwartship: 62 fore-and-aft: 33 depth: 18
after socket athwartship: 43 fore-and-aft: 33 depth: 34
strbd frwd sided: 77 moulded: 73

	forward notch		athwartship: 55	fore-and-aft: 36	depth: 17
	after socket	fore-and-aft: 28	athwartship: 43	depth: 34	
Bulkhead planks			thickness: 9		
Fin planks			thickness: 18 (approximately)		
Aft deck planks			thickness: 17-20		
Fin cheek knees,			lowerthickness: 47-44		
			upperthickness: 45-43		
Mast step	length: 825	sided: 120	moulded: 97		
	rake: 55 from forward edge of mast socket to centre of mast notch in mast beam				
Thole pins (6)	length: 600-750	diameter: 45-53			
Oars, rowing (6)	overall length: 11500	blade width: 170-230	handle width: 77-82		
steering (2)	overall length: 13500	blade width: 172-232	handle width: 78-81		

Bibliography

Bowen. L., 1949 — 'Arab Dhows of Eastern Arabia', *American Neptune* 9, Massachusetts.

Bowen, L., 1952 — 'Primitive watercraft in Arabia', *American Neptune* 12, Massachusetts.

Broughet, M. and Lishman, N., 1958 — 'Ships of Muscat', *The Mariner's Mirror* 44, London.

Casson, L., 1956 — 'Fore-and-aft Sails in the Ancient World', *The Mariner's Mirror* 42, London.

Coates, K.R., 1965 — 'Handling a Lateen Sail', *Yachting Monthly,* February, London.

Costa, P.M. and Kite, S., 1985 — 'The Architecture of Salalah and the Dhofar Littoral', *The Journal of Oman Studies,* Ministry of National Heritage and Culture, Muscat.

Fox Smith, C., 1942 — 'Arab Craft', *The Mariner's Mirror* 28, London.

Garrett, R., 1987 — *The Symmetry of Sailing*, Adlard Coles Ltd., London.

Hampton, L., 1939 — 'Building Dhows', *Yachting Monthly,* London.

Hawkins, C., 1977 — *The Dhow,* Nautical Publishing Co. Ltd., Lymington.

Hornell, J., 1941 — 'The Sea-going Mtepe and Dau of the Lamu Archipelago', *The Mariner's Mirror* 27, London.

Hornell, J., 1942 — 'A Tentative Classification of Arab Sea Craft', *The Mariner's Mirror* 28, London.

Hornell, J., 1970 — *Water Transport,* David and Charles, London (first published by Cambridge University Press, 1946)

Hourani, G.F., 1963 — *Arab Seafaring,* Khayats, Beirut (first published Princeton University Press, 1951).

Howarth, D., 1977 — *Dhows*, Quartet Books Ltd., London.

Lishman, N., 1961 — Arab Lateeners, *The Mariner's Mirror* 47, London.

McGrail, S. (ed), 1982 — 'Boat building Techniques, Technological Change and Attribute List, in National Maritime Museum Archaeological Series 7, Woodworking Techniques before AD

1500', *British Archaeological Reports* S 129, Oxford.

Ministry of Information and Culture, 1979 — *Oman, A Seafaring Nation*, Ministry of Information and Culture, Muscat.

Muir, J., 1965 — 'Early Arab Seafaring and Rudders', *The Mariner's Mirror* 51, London.

Paris, E., 1843 — *Essai sur la construction navale des peuples extra-Europeens*, Paris.

Prins, A.H.J., 1986 — *A Handbook of Sewn Boats*, Maritime Monographs and Reports No. 59, National Maritime Museum, London.

Severin, T., 1982 — *The Sindbad Voyage*, Hutchinson, London.

Severin, T., 1985 — Construction of the Omani *boom* Sohar, *Sewn Plank Boats*, BAR International Series 276, Oxford.

Sparks, W., 1909-10 — 'A Muscat Dhow', *Yachting Monthly* Vol VIII, London.

Villiers, A.J., 1940 & 1969 — *Sons of Sindbad*, Charles Scribner and Sons, New York.

Villiers, A.J., 1962 — 'Voyage in a Kuwaiti Boom', *The Mariner's Mirror* 48, London.