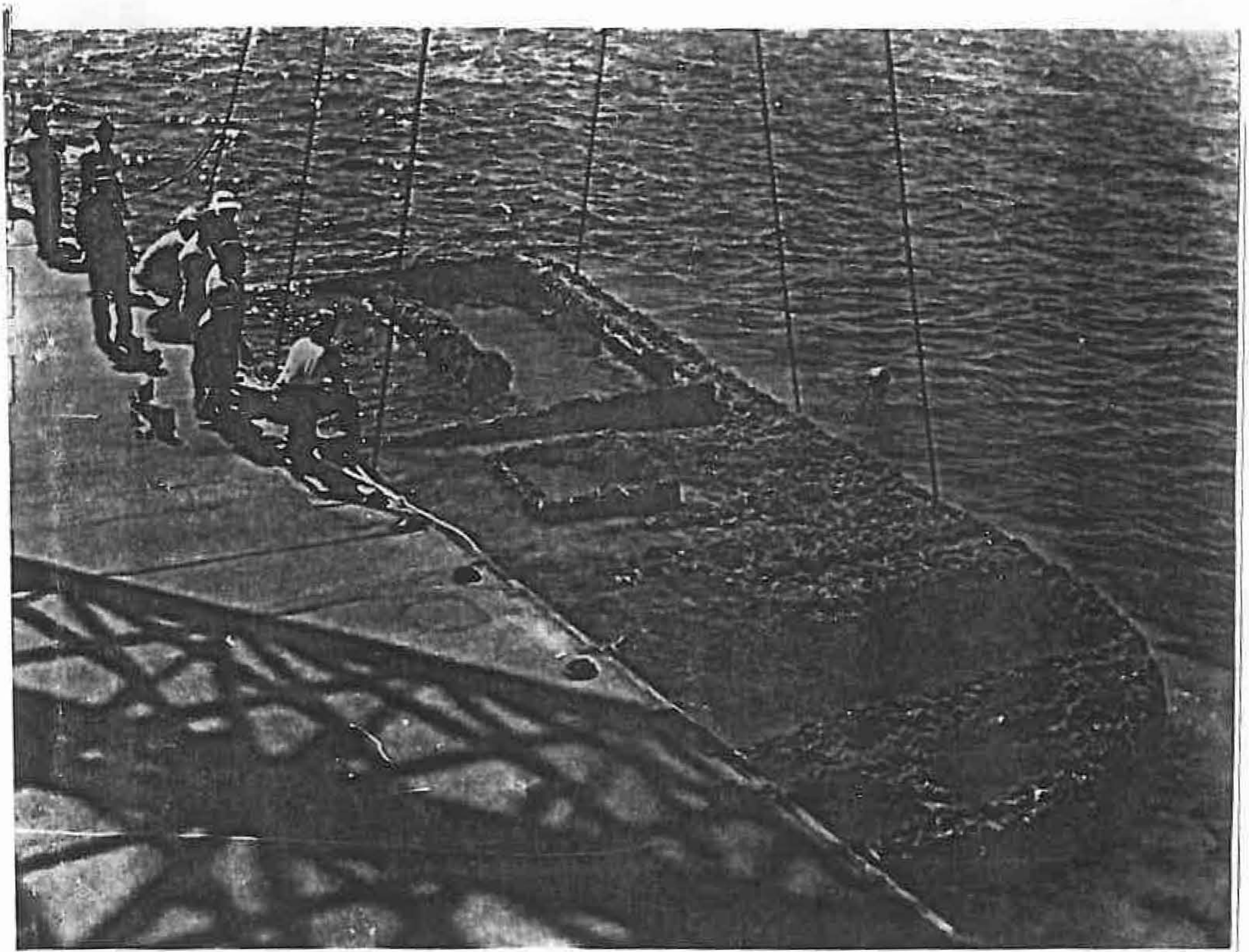
THE NORTH MOLE DREDGE:

A SURVEY OF AN UNIDENTIFIED WRECK.



CLASS OF 1990; GRADUATE DIPLOMA IN MARITIME ARCHAEOLOGY.

Report —Department of Maritime Archaeology, Western Australian Museum, No. 46.

Mike McC[illegible]

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Wreck Inspection
Maritime Archaeology Dept.
W.A. Maritime Museum
Cliff St, Fremantle 6160.

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Acknowledgements

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1.0 Introduction

The wreck of an iron dredge located off the North Mole, Fremantle, was selected for surveying as part of the 1990 Maritime Archaeology Graduate Diploma course. The dredge was chosen for its accessibility, its raised profile above the seabed (with the possibility of three-dimensional surveying), and with the intention of researching its history and confirming its identity.

The North Mole dredge is important archaeologically as there is a dearth of written information regarding vessels of this type. Much information must therefore be obtained from oral sources and photographic evidence before these sources are lost. Dredges have largely been ignored in historical literature, as they were considered 'mundane' and common. Their importance in the functioning of ports has largely been ignored, and few details recorded.

The North Mole dredge is a popular recreational diving spot, largely due to the ease of access and the abundance of marine flora and fauna around and on the wreck (Appendix I). While important recreationally, members of the diving community know little about the role the dredge played in the shaping of the Fremantle port. One of the intentions of this survey, therefore, is to raise public awareness of this wreck, and thereby increase public participation in the preservation of Western Australia's submerged heritage.

2.0 Research Aims

Through an extensive survey of the North Mole dredge it is intended to determine the vessel's type and function, its history and identification, and reasons behind its sinking. Management plans will be formulated, based on an analysis of conservation data.

3.0 Site Location

The "North Mole Wreck" is situated on the north side of the north mole lighthouse and to the west of the new extensions on the north mole itself. The location of the wreck was determined using two survey methods; sextant angles and G.P.S..

Four sextant angles were taken:

Incinerator chimney North mole lighthouse	91° 03'
Incinerator chimney Buckland Hill	82° 01'
Rottnest lighthouse Observation City	86° 04'
Rottnest lighthouse North mole lighthouse	71° 06'

The dearth of many prominent features from which to obtain sextant bearings, and the relation of the wreck to the few that were visible, meant a relatively large 'cocked hat' (of error), was obtained. The position of the wreck was estimated within this area and is shown in Figure 3.1. as position 1.

Fifty four readings were taken with the G.P.S. over a two hour period. During this time there were three satellites up and a two dimensional fix was established. A scattergram produced from the results showed two distinct groupings, centring around 115° 43.69' (long.) and 32° 3.16' (lat.) and 115° 43.64' (long.) and 32° 3.18' (lat.). These positions were adjusted in accordance with World Geodetic System 1972 Datum and are plotted in Figure 3.1 as 2a and 2b.

The two position estimates obtained from the present survey were compared with the plotted position on the Hydrographic Service Chart (Aus. 117). The sextant bearings placed the wreck considerably closer to the position plotted on the chart, than the G.P.S. readings. The differences in the positions of the G.P.S. can be attributed to the inherent inaccuracies of the chart and to the difficulties in applying a world geodetic system based on satellite, to a localised area.

To aid in the location of the wreck for the future reference of diving parties, photo transits were taken and are provided (Pl. 3.1, 2., 3.).

Pl. 3.1, Looking east, shows the relative position of the incinerator stack with a large pale brown rock on the top of the new mole wall to its right.

Pl. 3.2 , Looking north - east, shows the end of the groin corresponding to the base of Buckland Hill.

Pl. 3.3, Looking south-west, the relative positions of the lighthouse, the sign and Garden island might also be of assistance

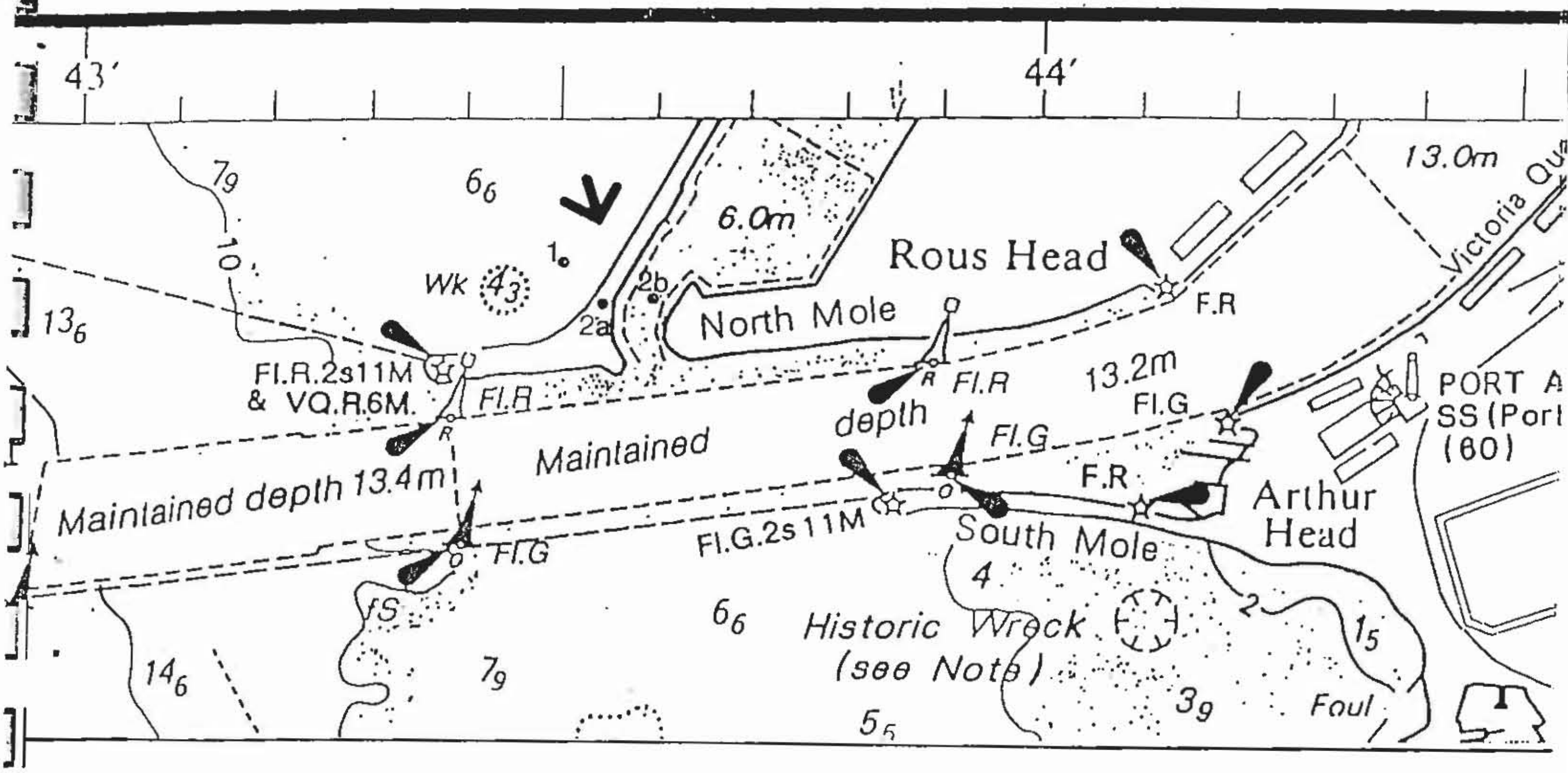
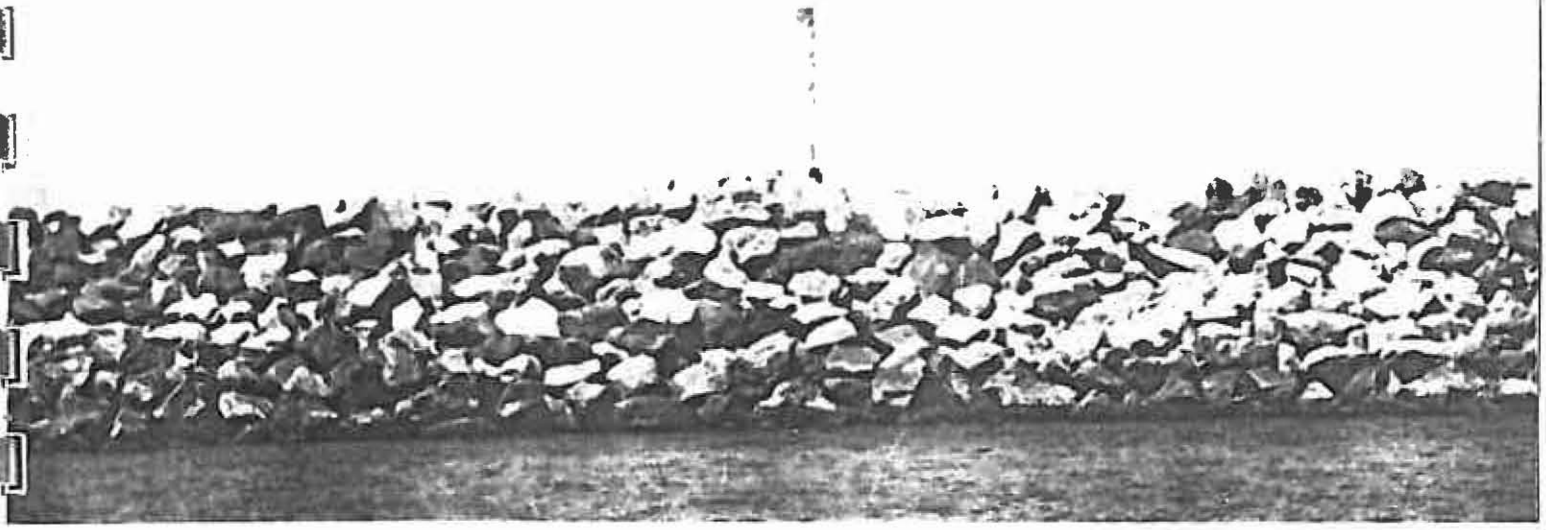

43′
44′
13.0m
Victoria Quay
6.0m
Rous Head
Wk
North Mole
F.R
Fl.R.2s11M
& VQ.R.6M.
Fl.R
Fl.R
13.2m
Fl.G
PORT A
SS (Port
(60)
Maintained
depth
Fl.G
Maintained depth 13.4m
F.R
Arthur
Head
Fl.G
Fl.G.2s11M
South Mole
Historic Wreck
(see Note)
Foul

Fig. 3.1



Pl. 3.1

Pl 3.2

Pl. 3.3

4.0 History

The North Mole dredge initially lay 200 m to the southeast of its present location. This original position is now marked by an incinerator built on reclaimed land during the recent harbour extensions. The dredge was destined for the 'sea graveyard' beyond Rottnest Island approximately 50 years ago, but appears to have been conveniently lost on the way (Robinson 1990:personal communication).

In 1988, with extensions being carried out in the area, the wreck was moved by the Department of Marine and harbours to its present location by request of the Western Australian Maritime Museum and local divers, so as to preserve it as a popular diving spot. It was moved by a floating crane which lifted the wreck partially out of the water (Figure 4.1) (Appendix III). As a result, the wreck is still in reasonable condition.

There is little published information on the operation of dredges within the port of Fremantle. Thus a more general history of the class of vessel as represented by the North Mole dredge is difficult to reconstruct. It is known a number of dredges which operated within Fremantle, were built under the direction of Messrs Coode, Son and Matthews, a civil engineering firm with offices in both London and Glasgow (Fraser 1896). Vessels constructed by this firm included the bucket dredges *Fremantle* and *Parmelie*, and the sand pump dredge, *Premier*. These vessel were all expressly built for the harbour works in Fremantle in the 1890s (Fraser 1896).

Other barges, *Pontoon A* and *Pontoon B*, were owned by the Public Works Department of Fremantle (Robinson 1986). The former sank and remained in the Swan River opposite the East Street ferry landing. Pontoon B was later upstream and sunk at Blackwall Reach (Robinson 1986). Newspaper accounts suggest the *Black Swan*, a steam dredge, worked removing seaweed from Rous Head in 1896 (*Inquirer* , 12 July 1889). The vessel was expressly altered for the work.

Further research into the position of dredges as part of a functioning port of the late 1890s, is necessary to clarify the function of the North Mole dredge.

Figure 4.1 Lifting of North Mole dredge from original resting place. (D. Robinson)

5.0 Survey Methods

5.1 Site Conditions

The wreck is situated on a sandy bottom at a depth of 9m and stands 3m above the seabed. The site is well protected from southerlies and easterlies but is vulnerable to winds blowing from the west and the north. Predominant winds from the west, restrict the number of working days on the site in winter.

5.2 Profiling

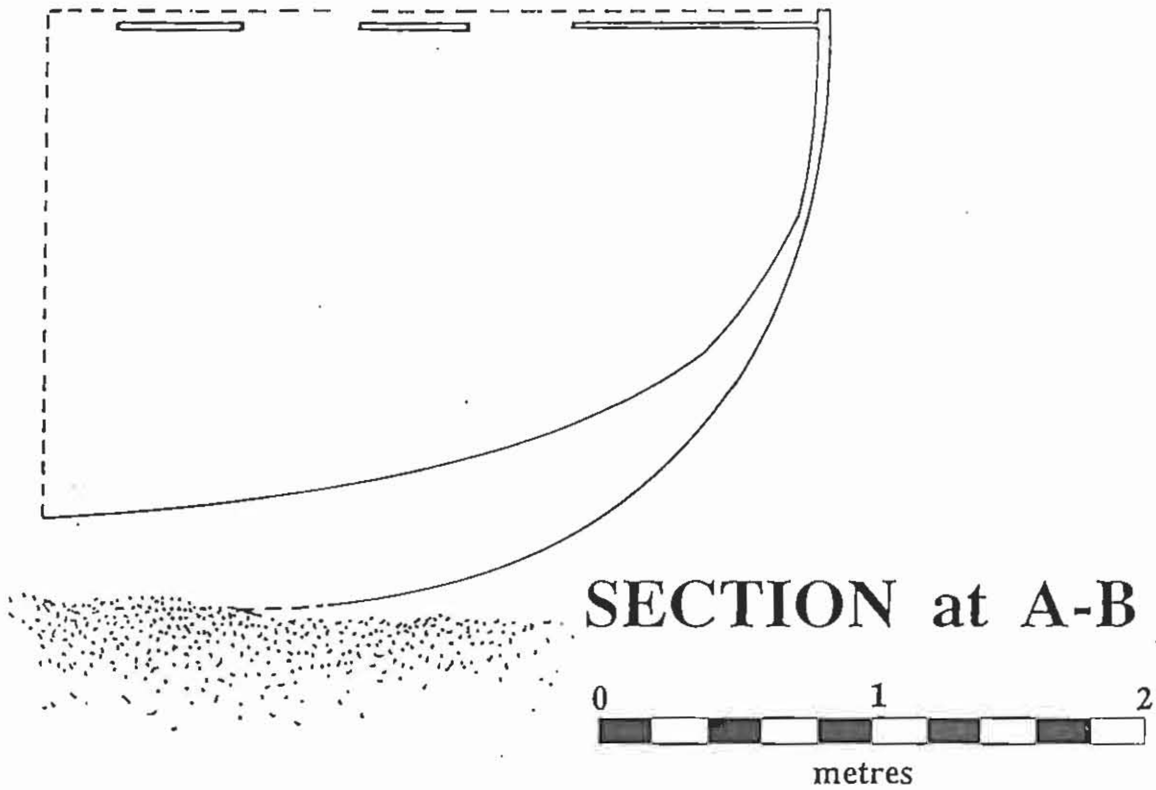
Profiling of the North Mole wreck was carried out in relation to the datum previously established along the vessel's length. Five profiles, both interior and exterior, were measured, as was an exterior profile down the stern of the vessel. The datum at the stern was transferred along the vessel's length to each profile station. This ensured that any height differences between stations and datum were taken into account in the plotting of profiles. The North Mole wreck appeared symmetrical, therefore it was only necessary to take profiles along one side (starboard).

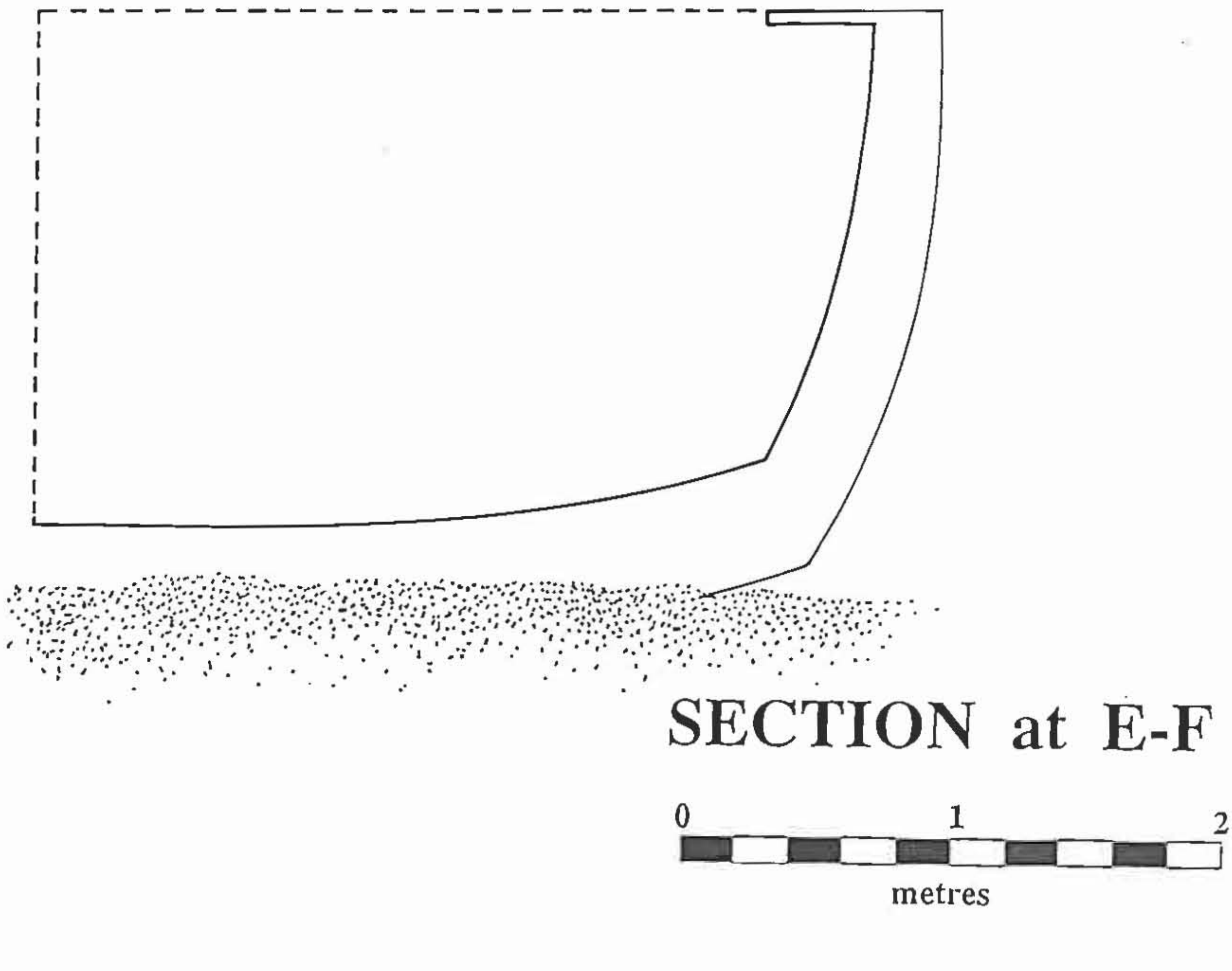
A number of different methods were used to measure the profiles depending on the conditions on the wreck site at the time and the profile to be taken. The first method involved use of the profiling device (Stations A-B and I-J) (Figures 5.2.1 and 5.2.4). This was the preferred method in conditions of strong surge or in confined places within the wreck. Its value was minimal where the profile being measured had long (over 1 m.) virtually straight lengths (such as the vessel upper exterior).

Method 2 was used only for interior profiles (Stations E-F and G-H) (Figures 5.2.2 and 5.2.3), and involved the attachment of a measuring tape to either side of the vessel at each station. The intersection of the tape with the datum line was taken to be the centre of the vessel. A tape with plumb-bob attached was dropped down to the base of the vessel at the centre-line and at intervals across the horizontal tape. This method could only be used in conditions of minimal surge as the weight of the plumb-bob was insufficient to keep taut the tape dropped into the vessel. It was not appropriate in confined or enclosed spaces where the horizontal tape could not be attached.

The third method was used for the exterior profiles. A tape with plumb-bob attached was dropped down the side of the vessel from each station. A length of wood with carpenters level and tape attached, was used to measure in from this tape to the vessels exterior. This method was also used to obtain a profile of the stern of the vessel (Figure 5.2.5).

Extensive marine growth covering the vessel was taken into consideration during measuring procedures, but errors from other sources have made necessary some fairing of the profiles. Surge through the wrecksite was the main factor contributing to this.





Figures 5.2.1 and 5.2.2: Profiles of the North Mole Dredge.

SECTION at G-H

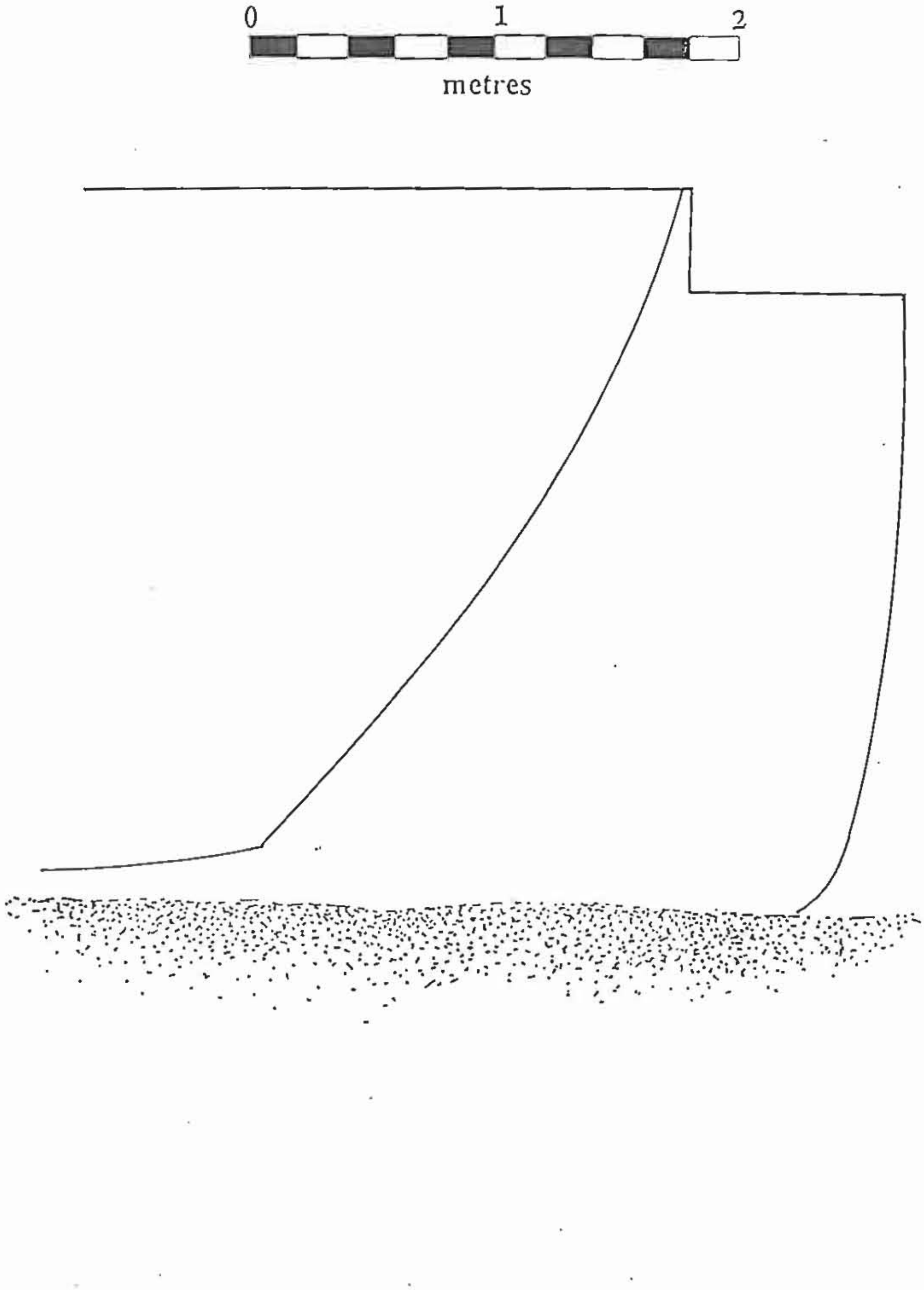


Figure 5.2.3: Profile of the North Mole Dredge, Section G-H.

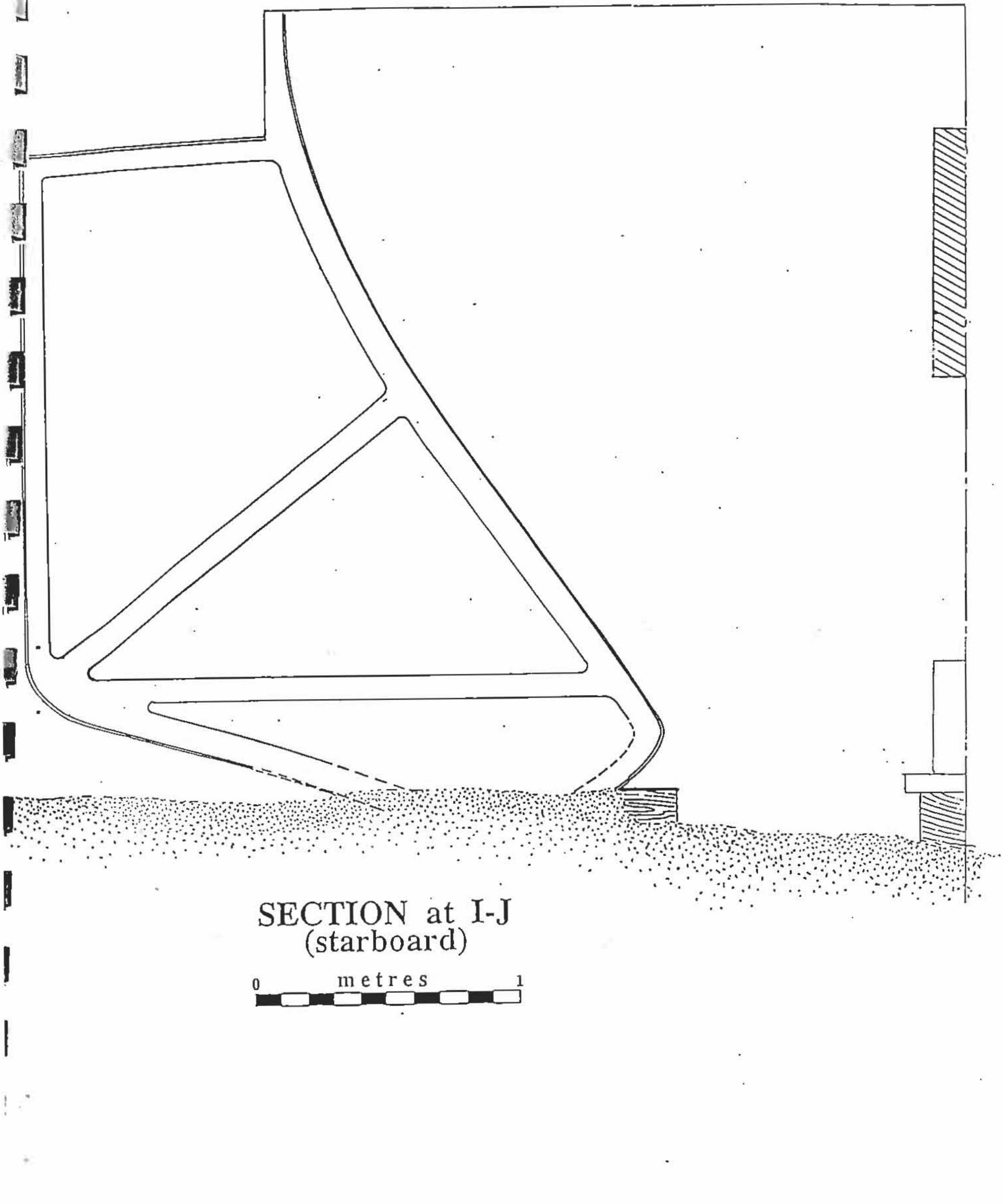


Figure 5.2.4: Profile of the North Mole Dredge, Section I-J.

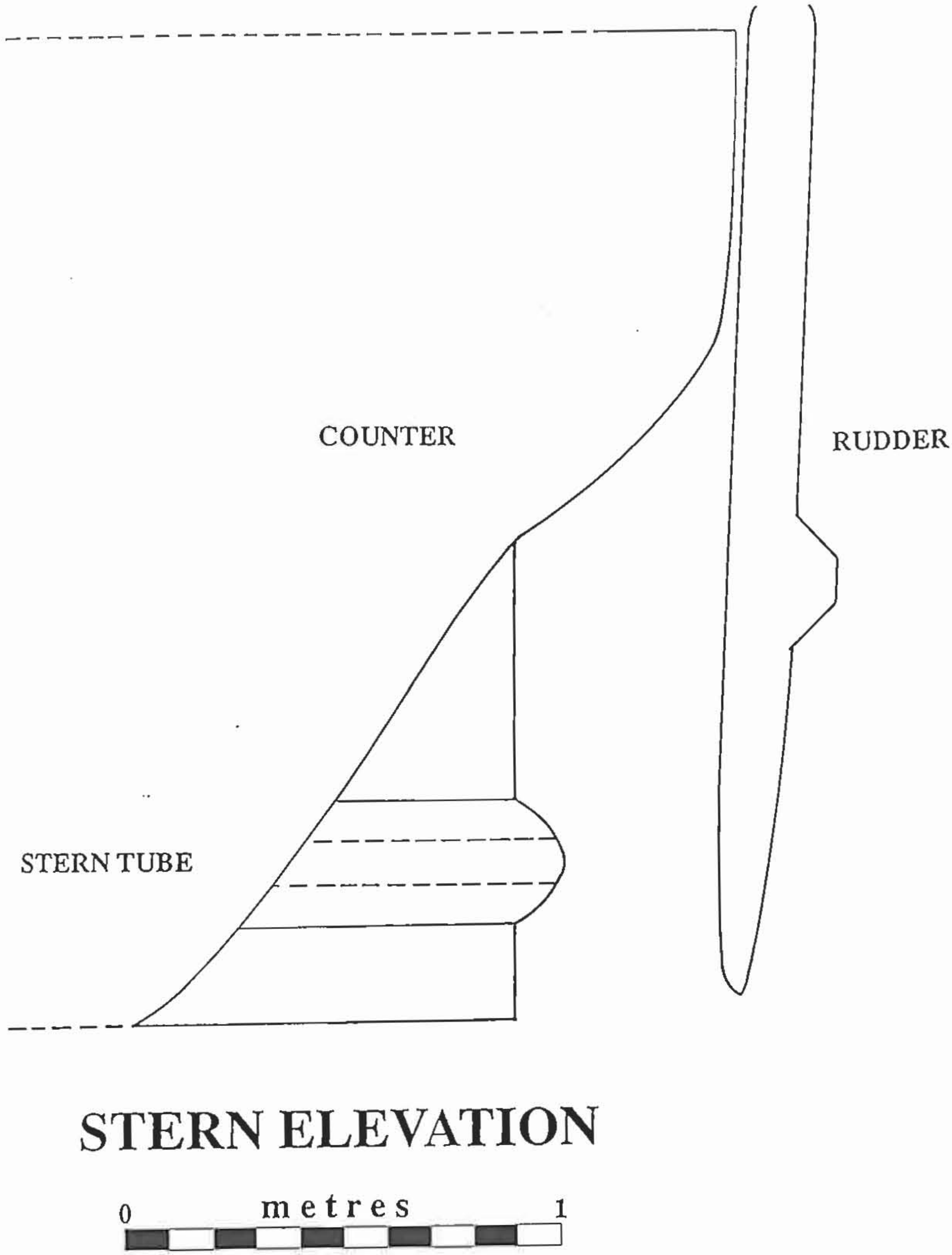


Figure 5.2.5: Stern elevation, North Mole Dredge.

5.3 Deck Plan

A baseline was established along the vessels length, with steel wire attached to either end by G-clamps. Offsets were measured from this to deck features, and tables of these measurements compiled. A site plan was generated from these offsets (Figure 5.3.1).

5.4 Isometric

As poor visibility hampered attempts to get an overall impression of the wreck, it was decided to generate the isometric drawing from the site plan measurements.(Figure 5.4.1). Additional vertical measurements required for the isometric view were taken during the course of five dives on the wrecksite. An isometric drawing of the boiler (Figure 5.4.2) was also completed. A sketch of the deck plan and the boiler were prepared on mylar film prior to each days dive and the measurements recorded on these plans.

New underwater drawing boards were designed especially for this project to accommodate A3 size mylar, printed with an isometric grid. Three such drawing boards were fabricated by Bob Richards and proved very successful.

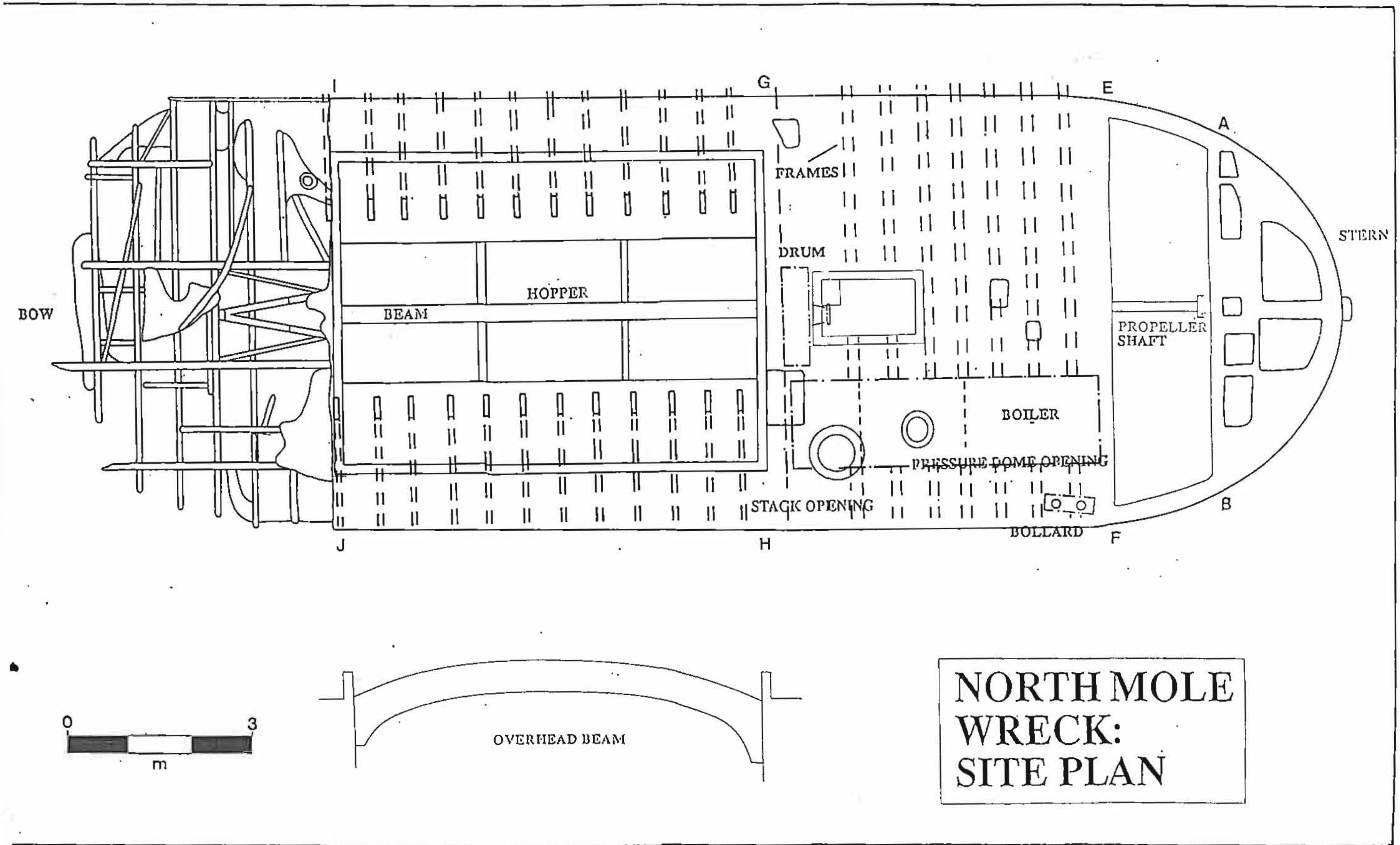


Figure 5.3.1: Deck and Interior Plan, North Mole Dredge.

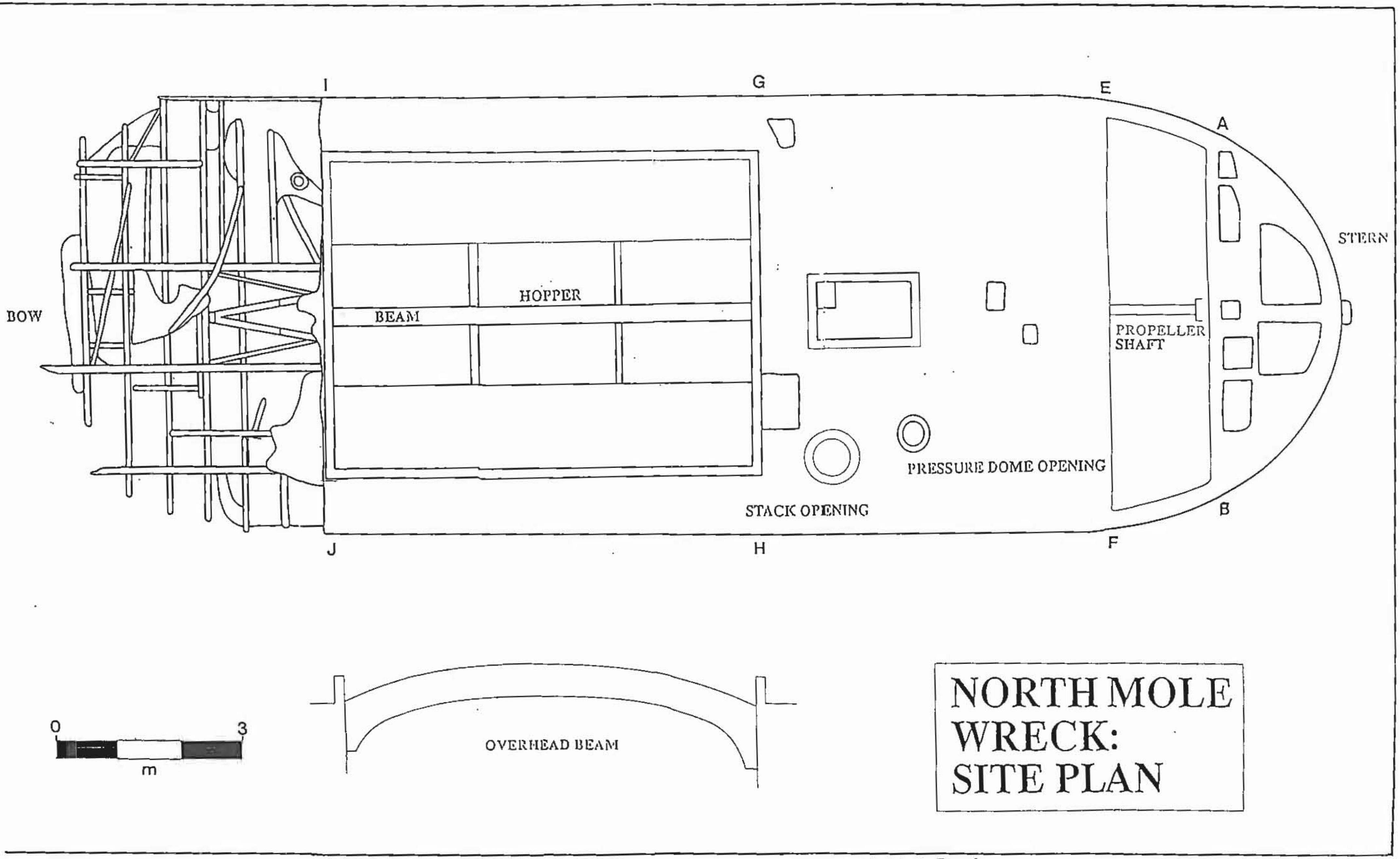


Figure 5.3.1: Deck and Interior Plan, North Mole Dredge.

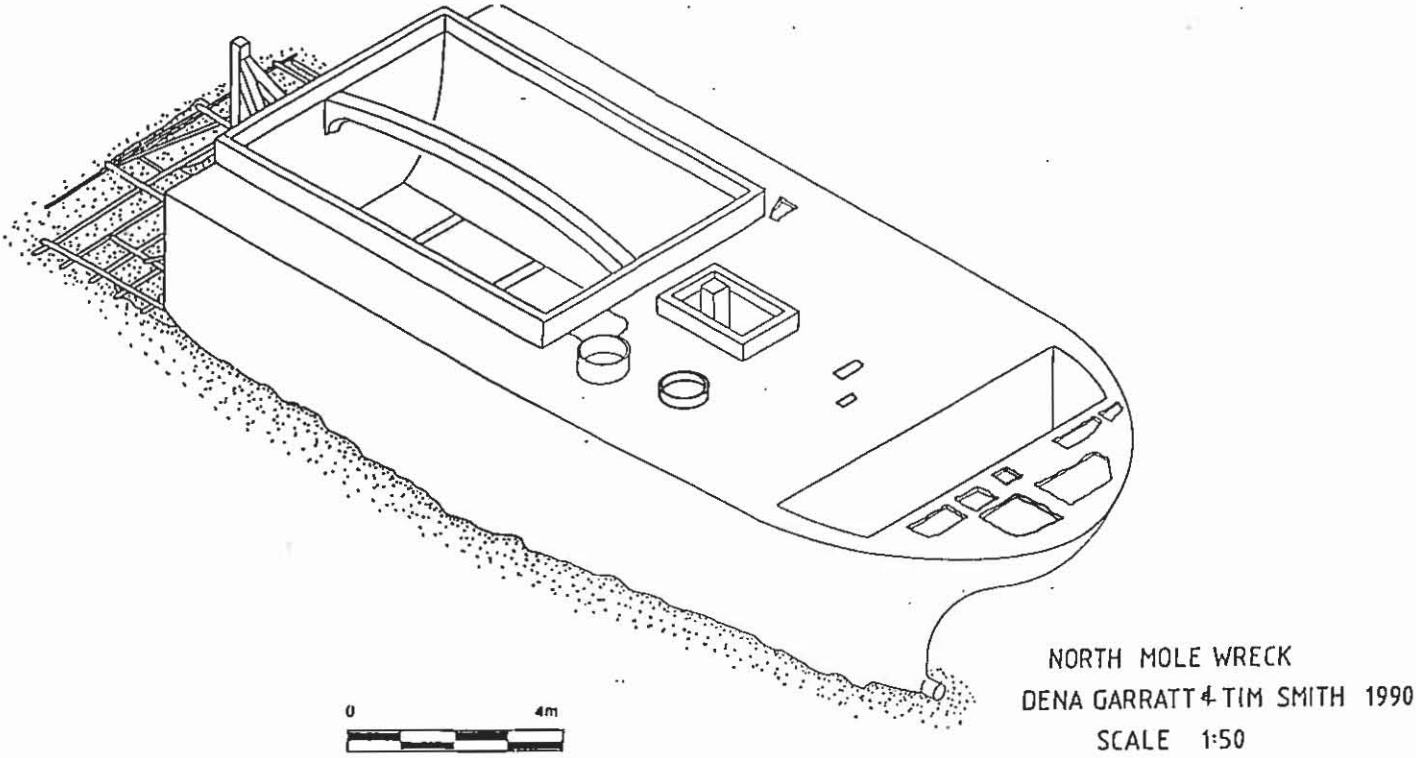


Figure 5.4.1: Isometric drawing, North Mole Dredge.

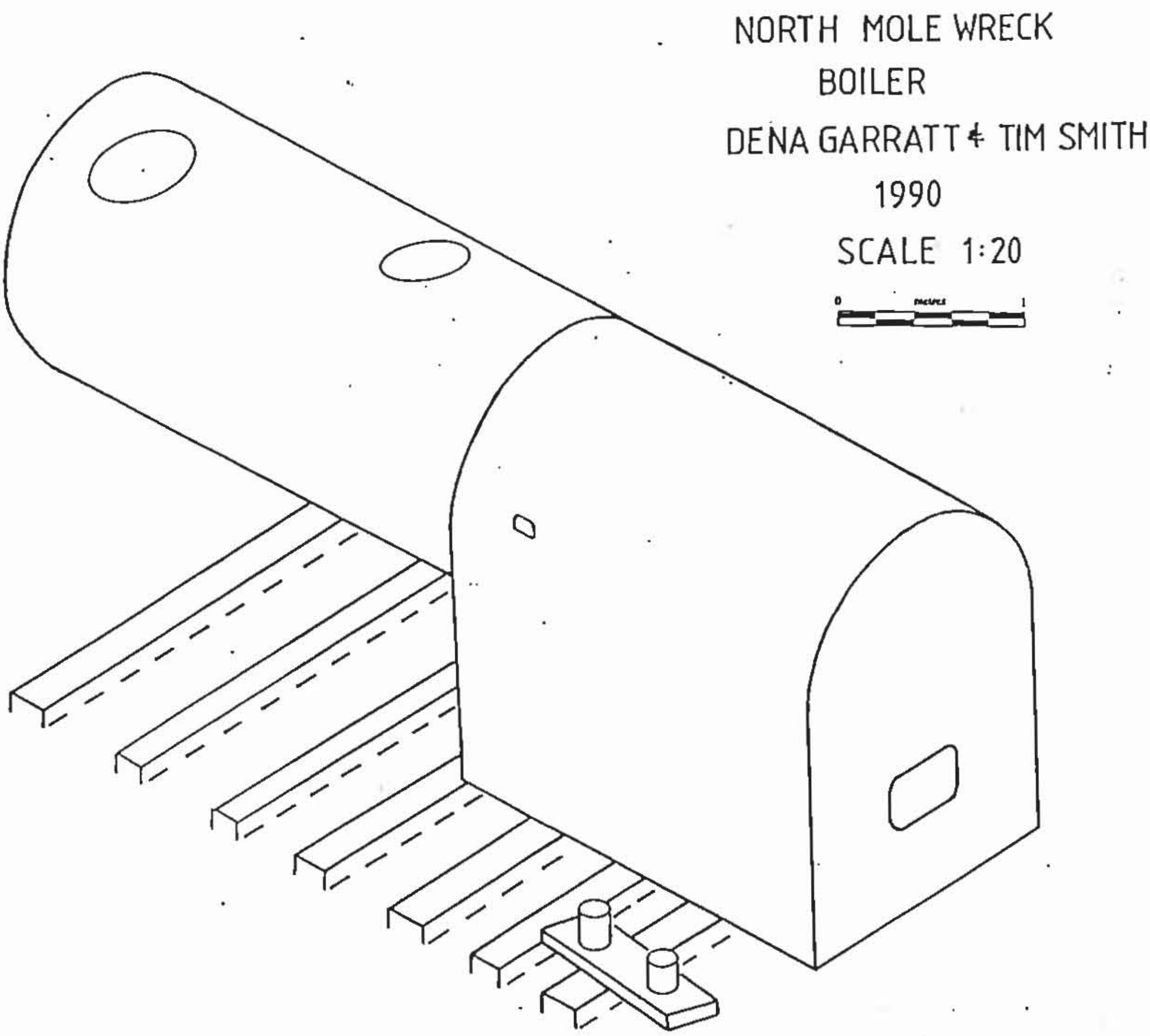


Figure 5.4.2: Isometric drawing of the boiler, North Mole Dredge.

Section 6.0 Construction

6.1 Major Features. The North Mole Wreck measures 20.5 metres in length, 7 metres in beam, and stands 3 metres proud of the seabed. It appears to be of rivetted iron construction, and the type of iron may be "lowmoor", which was known for its resistance to corrosion. The *Uribes*, wrecked off Rottnest Island, was built of "lowmoor" iron (McKenna, personal communication). Much of the bow is missing, with only a matrix of some of the iron transverse floor framing, side keelsons, intercostal keelsons and diagonal bracing (Figure 5.3.1). Some small pieces of hull plating are attached to the framing. The rest of the vessel, however, is fairly intact. With the exception of the stern, measured sections through the vessel at several points show a rather bulky, slab-sided configuration (Figures 5.2.1-3). She has a counter stern (Figure 5.2.5), with portions of a rudder still attached. There is a stern tube, the end of which has been welded shut. The iron deck has a very slight camber, and is pierced with numerous rectangular hatchways with coamings. Additionally, on the port side there is one round and one oval-shaped opening, with coamings, associated with the steam boiler. The boiler itself is dealt with in section 6.3. The most striking feature on the deck is the large (7.2 metres long by 5.12 metres wide) hatch surrounded by a coaming about 0.5 metres high, above the hopper of the dredge. Running longitudinally though the centre of this hatchway at about deck level is a large iron arched beam, sided .25 metres, and moulded from 1 metre at the ends to 0.45 metres through most of the rest of its length (Figure 5.3.1). It is thought that this beam supported the drive chains which helped to operate the doors on the bottom of the hopper. At the bottom of the hopper, there are the remains of heavy timbers, which may have been part of the doors on the bottom of the hopper (Figure 5.2.4). Wood was often used on the bottom of dredges which were being used in shallow water (McKenna, personal communication). Below deck, and aft of the large hatch is a piece of machinery which also may be associated with the functioning of the hopper doors (Figure 6.1.1). This is a drum, 1.58 metres in diameter and 0.4 metres thick. Tangent to one side is a rectangular chute running up through the deck in the forward starboard corner of one hatch. In the longitudinal view, the chute has a "dog leg" shape. Its upper end has been sealed with an iron plate. This may have been done at the same time that the stern tube was sealed, and could indicate a change in the mode of use of the dredge. In way of the hopper, between the hull skin and the hopper, are a series of iron braces to reinforce the sides of the hopper (Figure 5.2.4 and Pl 6.1)). These are spaced on centres 0.5 to 0.55 metres apart (Figure 5.3.1).

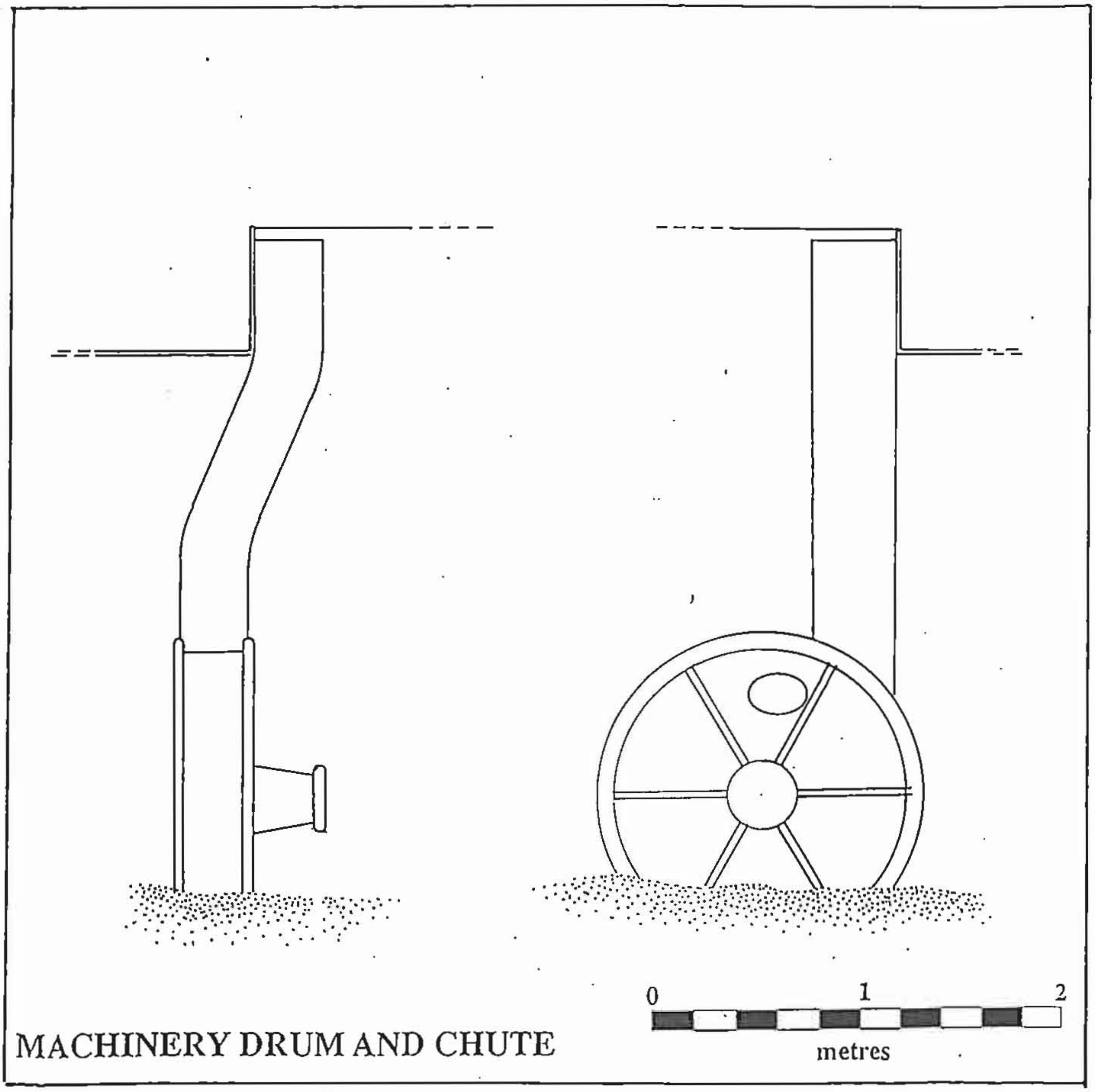
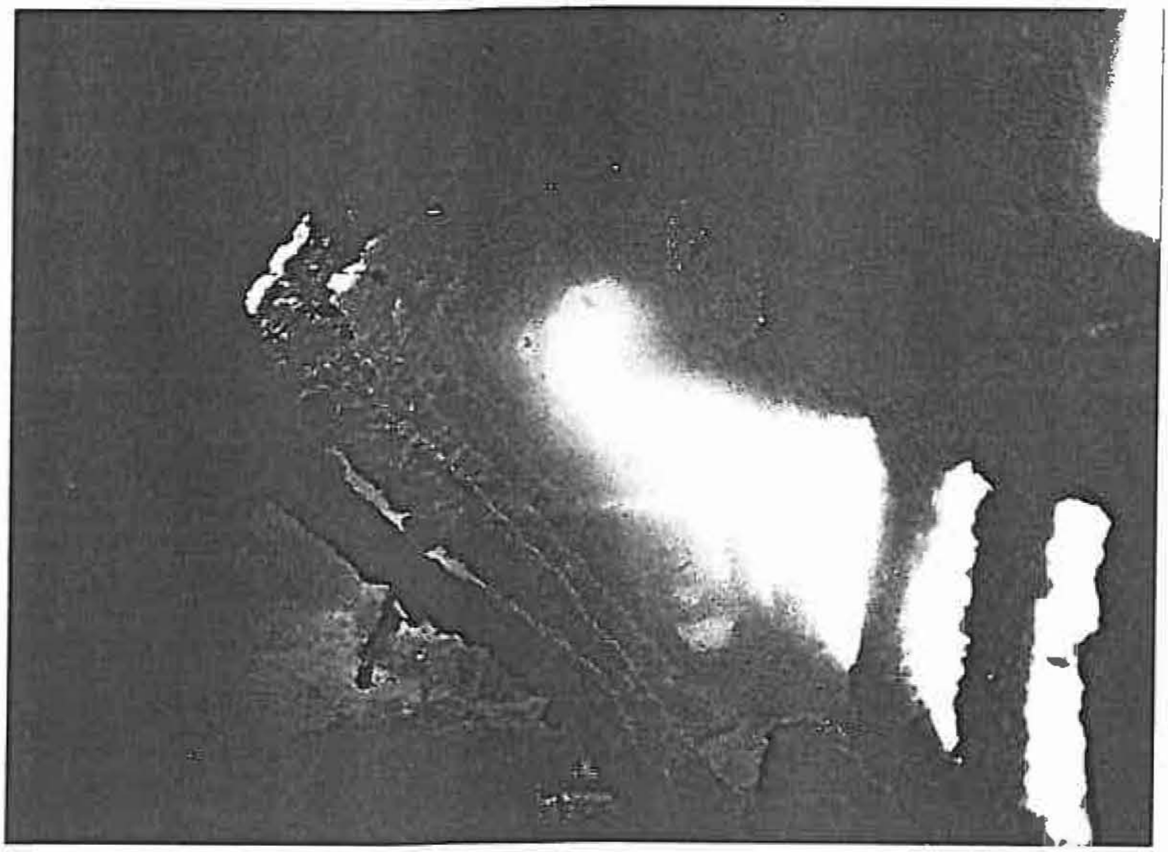


Figure 6.1.1: Machinery Drum and Chute



Pl 6.1: Photograph of Hopper bracing (hopper to the left)

Although some dredges (*Parmelia - D9*) had flotation tanks built into them (McKenna, personal communication), no evidence of these tanks was noted on the North Mole Wreck.

Inside the dredge, the propeller shaft, some 1.4 metres in length and 0.17 metres in diameter, lies in its approximate original position in the stern. To port and forward of this is the boiler, the details of which are dealt with in section. In this same area is also a double bollard, which has likely fallen through from its original position on the deck. Forward of the boiler is a bulkhead, with openings through into the area of the hopper (Fig. 6.1.2). Beneath the boiler, and throughout the section of the vessel that would have housed the machinery, are heavy transverse iron frames (Figure 6.1.3).

Accurate and detailed analysis of the assembly and rivetting of the vessel is impossible due to the heavy accumulation of marine growth.

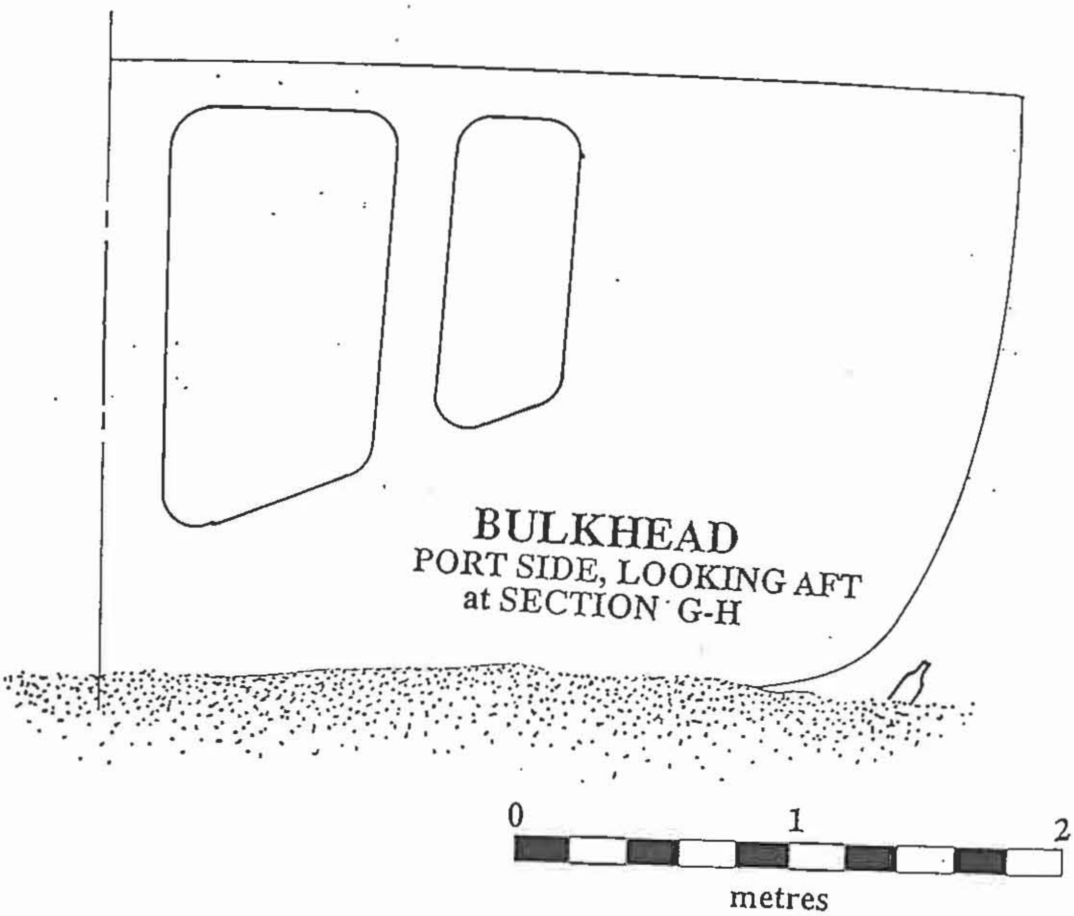


Figure 6.1.2: Bulkhead

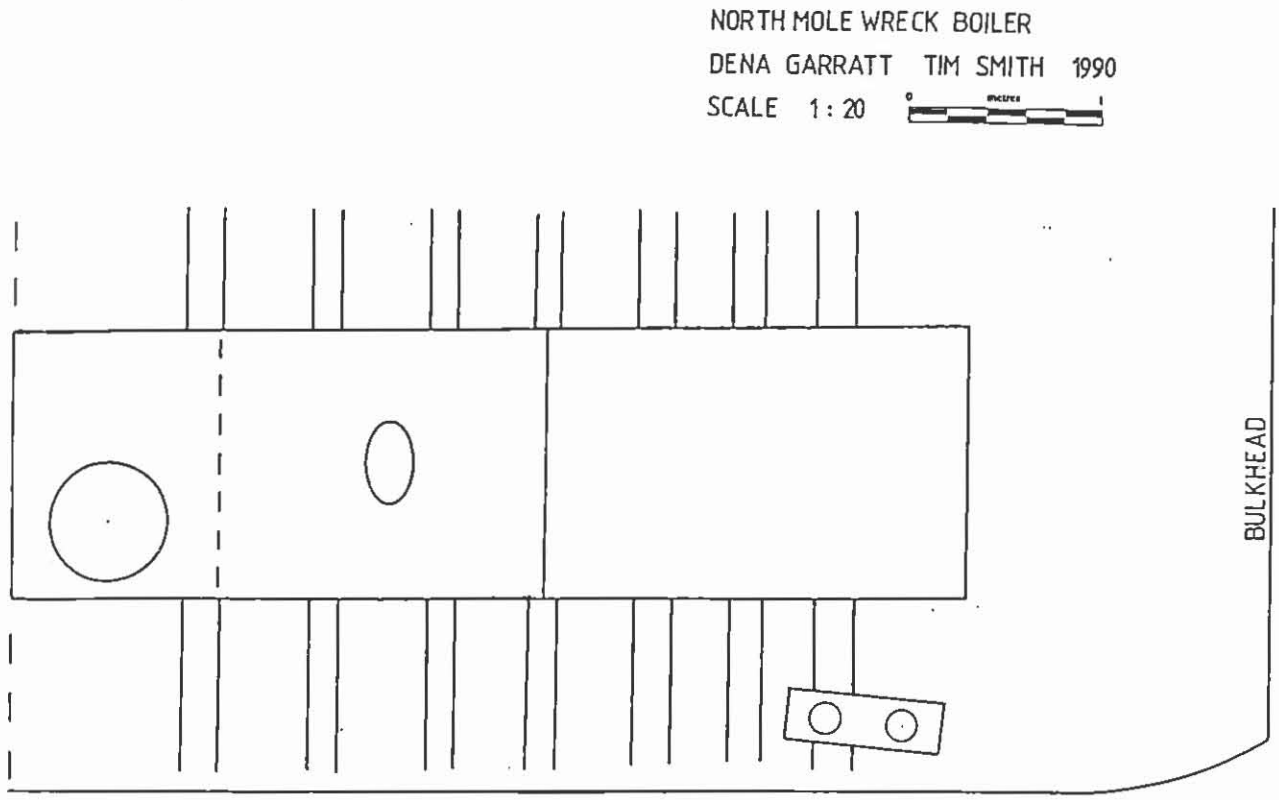


Figure 6.1.3: Framing under the boiler

7.0 Wreck Identification

The identity of the vessel is as yet unconfirmed. Both previous and present investigations indicate the vessel once operated as a dredge (Robinson 1986). In the booklet published by the Fremantle Port Authority in 1974, *Shipwrecks Around Fremantle*, the vessel was identified as the *Gareenup*. This is incorrect as the hull of the *Gareenup* was wooden, whereas the hull of the North Mole barge was of iron (Robinson 1986).

Previous research had isolated several possibilities for the identification of the dredge. The *Premier, No 5 Barge, Advance, Gareenup, Pontoons A and B, Parmelia, Fremantle, Governor and Black Swan* had been eliminated on the basis of previous measurements taken. Unconfirmed possibilities included the *Avon, 404 (ex Timaru)*, and *Priestman No 2*. The *Priestman* type , (so called because of the type of crane mounted on her deck) in particular, *Priestman No 2*, operated in the inner harbour as late as 1924 (Robinson 1986).

The most recent survey work, in conjunction with discussions held with Denis Robinson and Richard McKenna, has meant that the possibility of the North Mole dredge being identified as the *Black Swan*, cannot be ruled out. Early dredges, such as the *Black Swan* and the *Magnolia*, had low overhead beams across the skip, whereas the later barges, the *Governor*, *Premier* and the *Parmelia*, had high beams (McKenna 1990: personal communication). The North Mole wreck had a low beam.

Figure 7.1, of an unidentified dredge in Fremantle harbour bears a striking resemblance to the North Mole Wreck. The form of the two vessels is very similar. The overhead beam across the skip in the photograph appears to be at the same height above deck as that of the North Mole wreck. In the photograph, the stack on the port side of the vessel indicates there was a horizontal boiler below deck. The position and orientation of the boiler is the same as that of the unidentified dredge. It has previously been suggested that the vessel in the photograph may be the *Black Swan* (Robinson 1990: personal communication). The wooden decking which appears in the photograph does not exclude the possibility that this dredge is the same as the North Mole dredge. It appears barges and dredges such as these often had wooden decking overlaying the iron deck to enable work to be carried out on the deck on hot days (McKenna 1990: personal communication).

Photographs such as Figures 7.1, 7.2 and 7.3, may aid in determining the fittings and machinery which would have been associated with the wreck. This is particularly relevant with regards the fittings of the bow of the wreck.

The 1990 survey has been unable to establish what fittings or machinary were mounted upon the deck of the North Mole dredge. Further research and site investigation is necessary in order to determine the identity of the vessel, its layout and fittings.

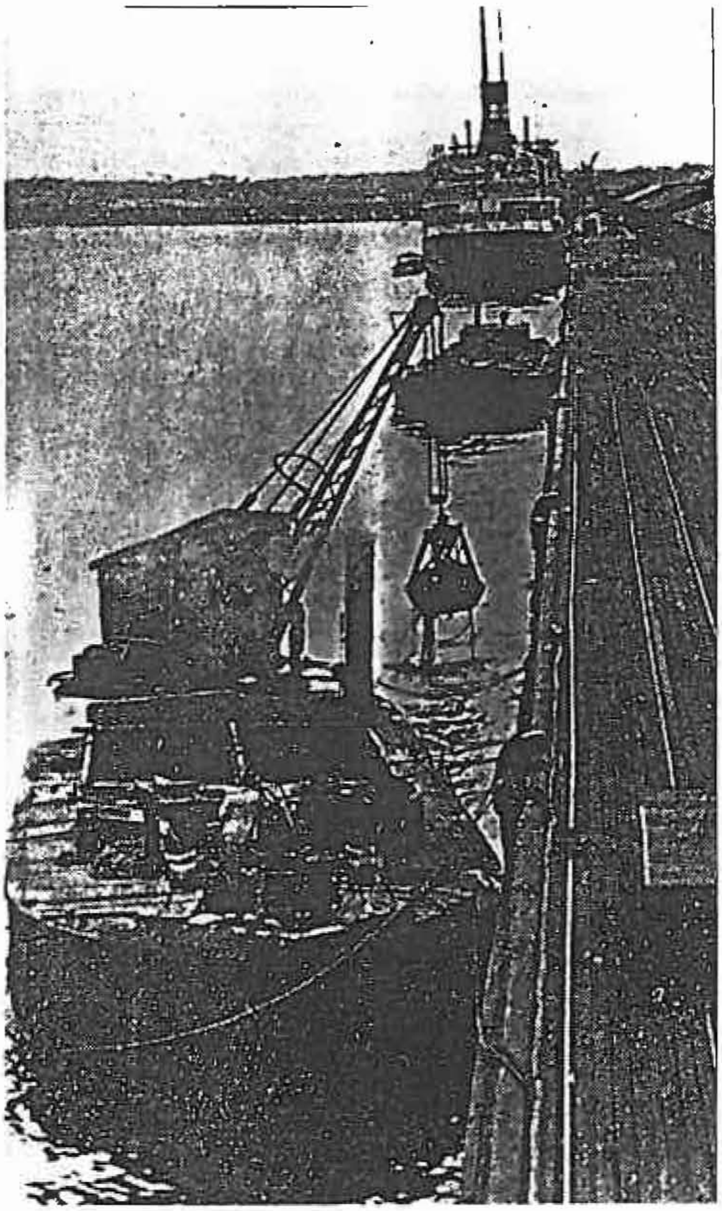


Figure 7.1 Dredge operating in the Inner Harbour, Fremantle. Possibly the *Black Swan* (D. Robinson).

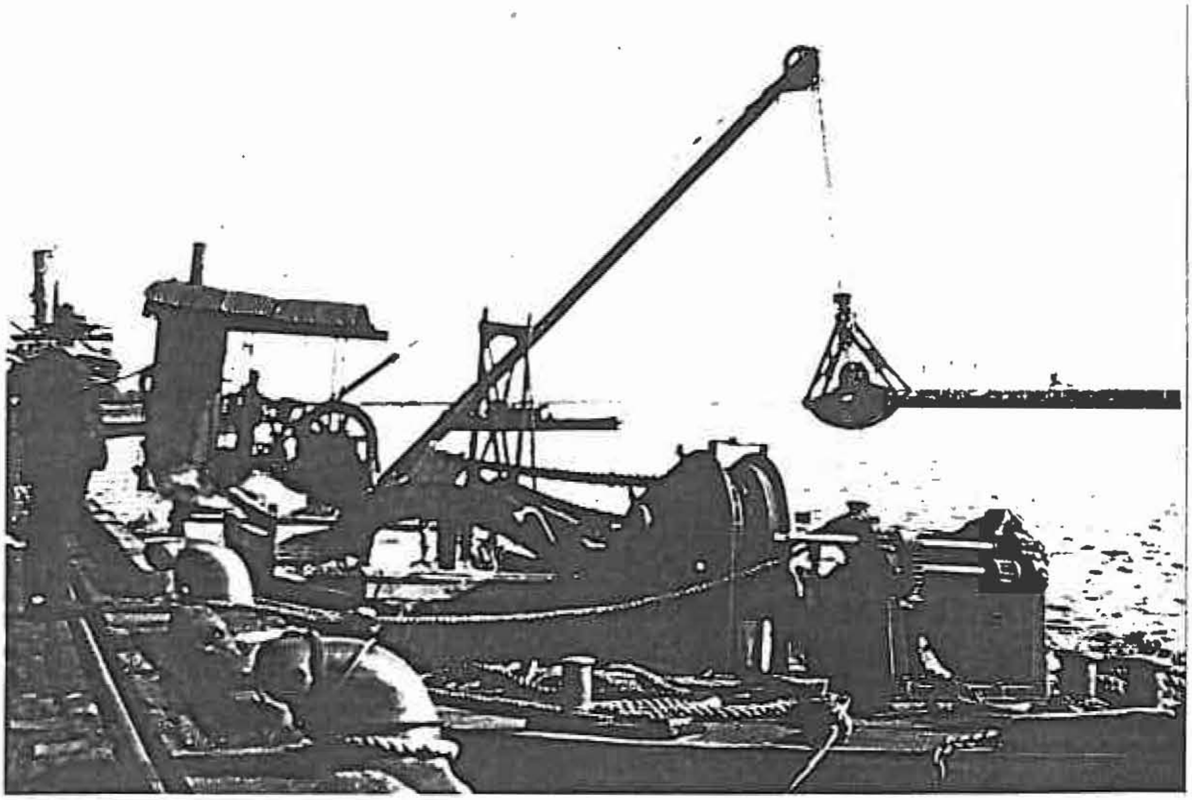


Figure 7.2 Priestman Type Dredge. Inner Harbour, Fremantle (R. McKenna).

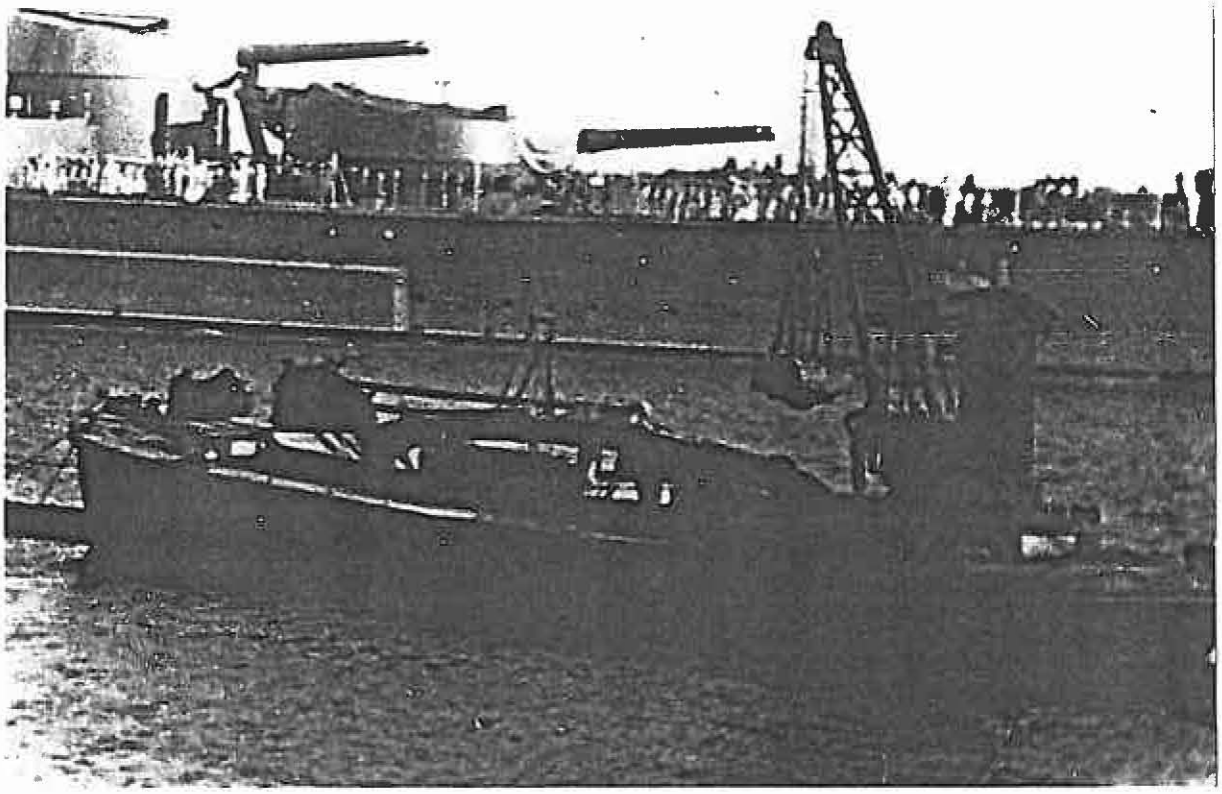


Figure 7.3 Priestman Type Dredge. Inner Harbour, Fremantle (R. McKenna).

8.0 Conservation and Site Management

8.1 Introduction

The North Mole wreck-site, lying in State waters and having foundered since 1900, does not fall under any protective legislation. Were it in Commonwealth waters it is likely that it would have been protected. The site does not appear to fall under any of the categories of the *Historic Shipwrecks Act* (1976) (a) to (f) below (Ryan 1977:25);

a. A wreck significant in the discovery, early exploration, settlement or early development of Australia.
b. Relevance of a wreck to the opening up or development of parts of Australia.
c. Relevance of a wreck to a particular person or event of historical importance.
d. The wreck is a possible source of relics of historical or cultural significance.
e. The wreck is representative of a particular maritime design or development.
f. Naval wrecks other than those deliberately scrapped or sunk and having no particular historical or emotional interest.

A further criterion was indeed added to the list in 1981 (McCarthy, 1983) following the publication of an article about the educational and recreational significance of wreck sites (McCarthy, 1980);

g. A wreck has an educational and recreational interest apart from its historical value.

It is this criterion which would probably have resulted in the legal protection of the wreck were it in Commonwealth waters.

Interestingly we should note that the wreck has already been saved from destruction in the North Mole Harbour extension work of 1988, when it was lifted by crane and moved to another accessible site (see Appendix II). This was done on the grounds of its value as a simple novice dive, frequented by many particularly for dive training.

Our studies then have suggested that there are no reasons to establish major conservation work on historic grounds so this conservation and management project is designed as a proposal within this context.

Why bother doing any preservation work? Having considered the issues we feel that the maximum value can be obtained from this site only as a source of more than continued recreation.

Indeed the accessibility of the wreck, its comparatively whole condition and its position, both close to a place of study and at the centre of a variety of interesting wrecks in the area, have led to clear possibilities for the north mole site.

8.2 The Proposal

This proposal aims for;

a. The creation of the wreck as an 'underwater corrosion laboratory', that will allow testing of various corrosion theories.
b. A scheme to promote responsible wreck diving.
c. A means for amateur wreck divers to participate in maritime archaeology.
d. The creation of greater involvement by the local sport diving industry.
e. Instigation of contacts with off-shore oilfield corrosion expertise for mutual benefit.
f. Provide sponsorship to carry costs of promotion and equipment.

The scheme aims to be comprehensive and has means to instigate these intentions in a variety of ways using the factors listed below.

8.2.1 The Fremantle Wreck Trail

The North Mole wreck site could become the starting point for a wreck trail that comprises a wide variety of sites that are safe, accessible and suitable for encouraging diver activity. Part of a wider range of wreck trails along the whole coast, it would support the principle that encouraging wreck diving of the right type will benefit maritime archaeology. It certainly dispels the belief that maritime archaeologists only take things from divers rather than give things to them. Also a wreck that is visited frequently is in a sense better protected than many other archaeological sites. This is because whilst some movable items may be lost, the wreck is popular and loved, thus there is a reason to preserve it. In addition, the pressure of the local diving is taken away from the other dive sites.

This proposal is designed to support all this and be part of the principles behind promoted wreck trails.

The planning of such a wreck trail is already underway by Mike McCarthy, Inspector of Wrecks, Department of Maritime Archaeology, Western Australian Museum (WAM).

8.2.2 The Wreck Diver's Passport

The Wreck Diver's Passport utilises a number of the sites that are indicated in the Wreck Trail planned by Mike McCarthy. The intention of the Passport is to provide a means to encourage and qualify divers who wish to participate in wreck diving and amateur Maritime Archaeology. When a designated number of wrecks have been visited by the diver and stamped by the participating dive boat skipper, school or shop, the diver can join a Maritime Archaeology association and become involved in the North Mole Wreck laboratory.

This will weed out those who are not willing to involve themselves over a period of time. In qualifying themselves in this way they will be able to participate in the work on the wreck that is centred on both the underwater laboratory project and the museum. The participating divers will benefit from this involvement as will the museum's research.
The passport is illustrated in the Appendix.

It shows a brief history of each wreck and has space for the relevant signature and stamp. An example of the wreck stamps are also included and the passport would be available free at the museum and participating dive shops. The passport would be signed up and stamped at a variety of locations by the participating bodies.

When the diver had visited a designated number of wrecks he could then apply to join in with the laboratory work that would be organised by the relevant local Maritime Archaeology association in conjunction with the WAM.

The Wreck Diver's Passport will promote responsible diving on archaeologically safe sites. It will encourage participation and liaison between the museum and the local sport diving industry. They in turn will benefit by encouraging more diving activity.

8.2.3 The North Mole Wreck-site as an Underwater Research Laboratory

This is proposed to be a useful long-term means to acquire valuable, reliable data of assured quality to test out and develop theories of underwater corrosion on wreck sites. It would involve a number of surveys over a period of years using pro-forma data sheets and procedures designed with the principals of modern industrial quality assurance. These will provide the input for a database that will enable a wide variety of trend analyses for theory evaluation and development.

It is the way in which this proposal intends to create more than recreational reasons for protecting the North Mole wreck site.

8.2.3.1 Methodology

A cathodic protection system will be installed on the North Mole wreck site of suitable composition, size and positioning (to be determined).

Pro-forma data sheets will be drawn up to provide consistent, repeatable and reliable data of assured quality. Examples of the type are shown in Appendix II. Their final design would not be determined until the exact nature and extent of the cathodic protection system and the extent and type of the surveys required are determined. Just two are included here one for C.P. and p.H. readings and one for marine growth surveys to assess any species change after protection. Other surveys would be nominated and designed once an evaluation of required areas of study was determined.

A suitably durable corrosion potential meter would be acquired for obtaining C.P. data, ideally a Roxby Bathycorrometer Mk V. Stringent calibration and operational procedures would be required to ensure that data is comparable between surveys.

Divers will qualify to undertake the surveys through the Wreck Diver's Passport scheme and their involvement with the relevant local Maritime Archaeology association.

Monthly and annual surveys would be considered and instigated accordingly and the data obtained over a long period. The data would be given to a responsible member of Museum staff who would be liaison officer for the project and would check that the pro formas were correctly filled out, check in and out the equipment, and ensure its basic maintenance and charging.

The data would be entered into a suitable database and made subject to the relevant statistical analysis (examples of which are described in 8.2.3.3)

8.2.3.2. Costs and Finance

The above proposal requires the provision of a number of items: in particular the provision of the sacrificial anodes and the Bathycorrometer. Given the existence of a wide variety of industrial corrosion companies, consultants and experts in this region it seems of great benefit to establish wider contacts between them and the Museum.

Those at Woodside petroleum who deal with corrosion analysis would be of great use. Initial contacts already made with Woodside Underwater Engineering indicate a possible willingness to provide materials or financial assistance. We would recommend pursuing this as they would be ideal sponsors given the extent of their financial and intellectual resources.

The local sport diving industry would be pursued to cover the printing and other minor costs.

8.2.3.3 Data Analysis

It is proposed that data is collected by individuals and the completed pro-forma data sheets handed by them to an analysis co-ordinator. Data could be readily analysed with the aid of the Apple Macintosh StatView II program (or any available standard statistics package). Ideally, a number of separate readings for each specified time-period would be taken by different divers to ensure some means of quality control over the data.

Analysis of the data would have two distinct phases. Firstly, there would be the combining of the (most probably differing) results recorded by different divers in the same time block. Standardized C.P. readings (E_{corr}), pH measurements, water depth, and concretion thickness measurements should all be recorded for each specified location. Overall water temperature should also be recorded. A scattergram illustrating the data set for each location can then be viewed. Given a sufficiently large data set for each location, outliers could be rejected. If the majority of one diver's readings differed greatly from all others, some investigation into the possible reasons for these discrepancies might be worthwhile.

Once a relatively homogeneous data set is obtained, the mean values for each parameter at each location can be calculated for each time-period. It would then be helpful to view some graphical analyses of the data. A scattergram of standardized E_{corr} readings and of pH values across the wreck will immediately identify similarities and differences between locations over the site. A chart showing E_{corr} readings plotted against pH measurements will illustrate the variation (or not) of the corrosion state between the various locations. When this same data is plotted on a Pourbaix diagram for iron (steel can be assumed to corrode similarly to wrought iron), the stage of corrosion at each location can be identified as inert, passive or active. It will also identify the predominant compound of the iron.

As an example, let us look at data collected on the North Mole wreck on 24, August, 1990 by Jon Carpenter, Madeleine Gauntlett and Ed Punchard. Results were recorded for each location as marked on the pro-forma sheet.

The E_{corr} readings were adjusted (by adding 0.268V) for reference to the silver/silver chloride reference electrodes used and were then found to be markedly higher than would be expected on a site at a depth of 7m according to research conducted on a variety of wreck sites off the coast of Western Australia, which led to the conclusion that corrosion potential for both wrought and cast iron objects is linearly dependant upon water depth (MacLeod, 1989: 229). The fact that the data was remarkably consistent (bar the one location 14) implies that the problem is one of adjustment necessary for all data points. Further adjustment which would be necessary were there an air bubble in the connecting line of the meter (subtracting 0.230 V) yielded results which accorded with the expectations. The validity of such an adjustment is obviously questionable: there is no positive proof that an air bubble was the problem. However, whilst highlighting the need for equipment with assured quality control, this adjustment is used for the data which follows (see Table 1).

Location	Adjusted E_{corr} (Volts)	pH measurement
1	-0.371	7.29
2	-0.369	8.50
3	-0.369	7.90
4	-0.362	7.10
5	-0.374	7.33
6	-0.362	7.57
7	-0.366	7.03
8	-0.370	7.26
9	-0.356	7.49
10	-0.365	7.24
11	-0.351	6.95
12	-0.360	?
13	-0.351	7.32
14	-0.454	8.52
15	-0.347	6.86

Table 1 Corrosion potential and pH readings

Location	Water depth (m)	Concretion thickness (mm)
1	6	10-15
2	8	5
3	8	10-15
4	6	10-15
5	8	10-15
6	8	10-15
7	7	10-15
8	6	10-15
9	6	10-15
10	6	10-15
11	6	10-15
12	8	5
13	6	10-15
14	8	50
15	8	10-15

Table 2 Water depth and concretion thickness measurements

Figure 8.1 clearly indicates the homogeneity of the data with the glaring exception of an 'outlier'.

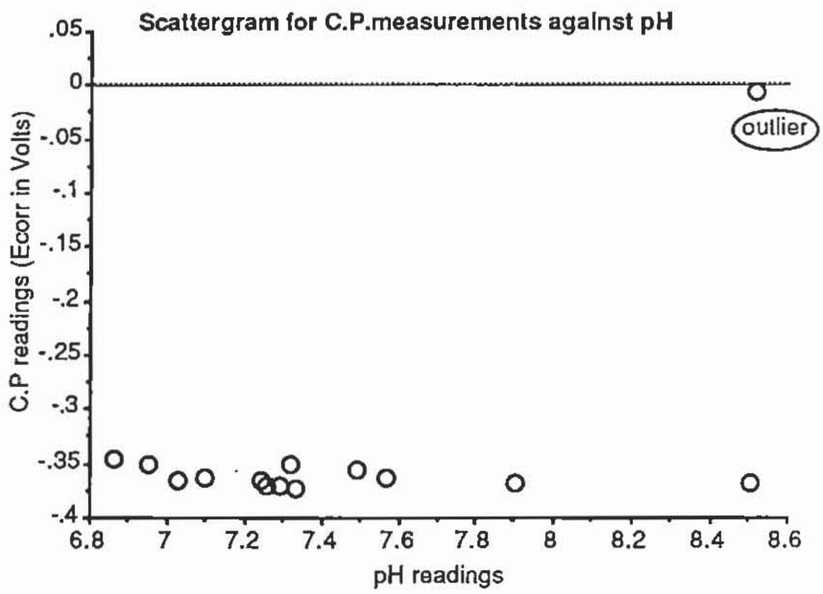


Figure 8.1 Scattergram of C.P. readings against pH measurements

A chart plotted using 15 divers' readings for one location might appear similar if one diver had made an error in taking the reading. The 'outlier' (originating from completely different reasons from the one in this chart) could then be rejected after further investigation before calculating a mean from the homogeneous results.This mean could then be used as follows to asses the contemporary rate of corrosion.

The results illustrated in Figure 8.1 were plotted on a Pourbaix diagram for iron (see Figure 8.2). The position of the 'outlier' is shown as is that of the mean of the other locations. It should be noted that the Pourbaix diagram illustrated concerns the behaviour of iron at 25°C and at atmospheric pressure. The water temperature recorded for this data set was only 13°C. The slope of each line on the Pourbaix diagram depends, amongst other things, upon the water temperature. However, since the consideration is of absolute temperature, a difference of 12°C results in only a very small slope change.

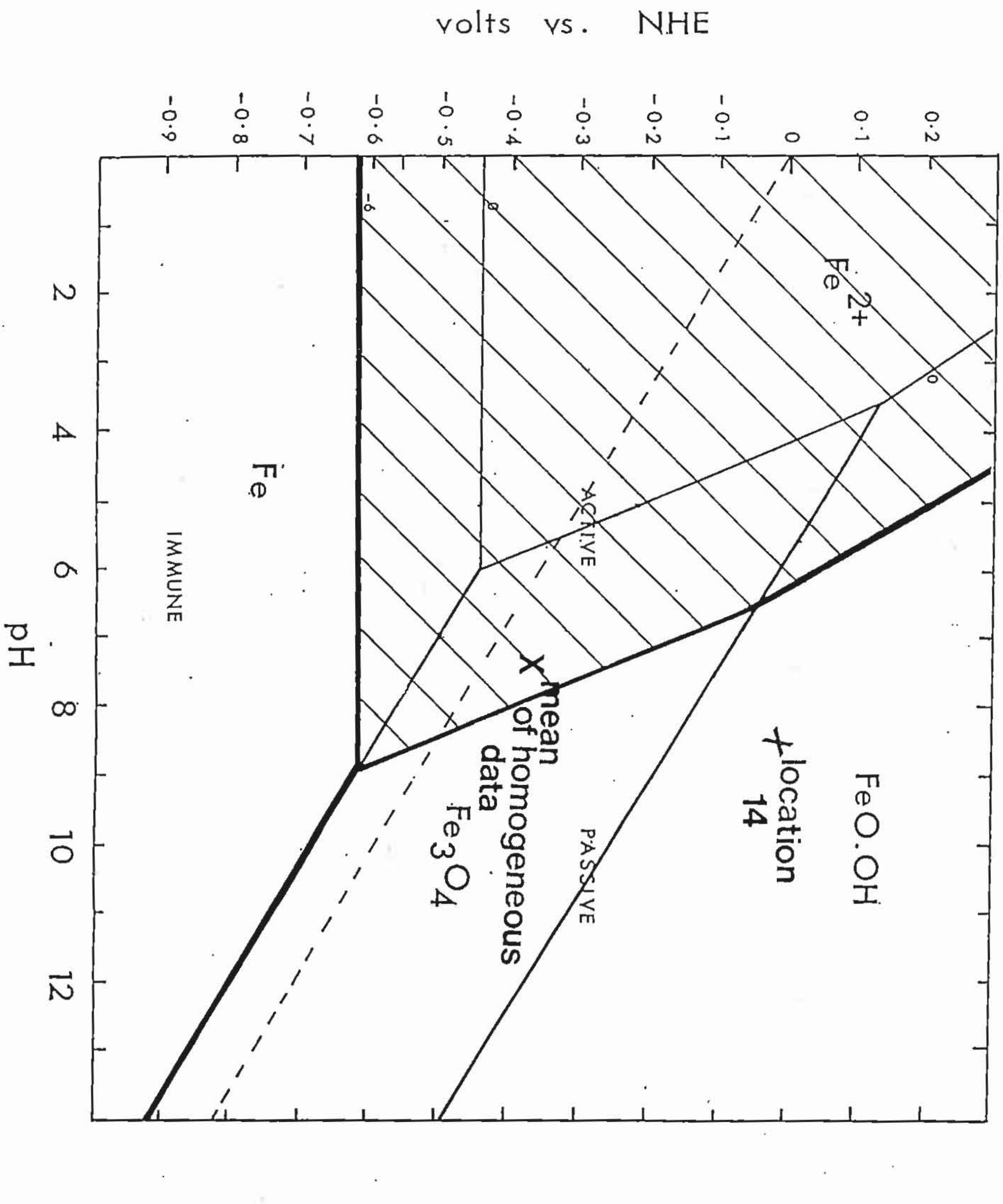


Figure 8.2 Pourbaix diagram for iron showing data points

It can be seen that location 14 actually consisted purely of iron corrosion products, no metallic iron remaining. Its high pH reading, virtually that of seawater itself accords with this result. Location 14 was actually on a piece detached from the main structure. The homogeneity of the other locations' data permits valid discussion of their mean value. This shows that the main body of the wreck is in a state of active corrosion, Fe^{2+} ions being produced as corrosion products.

A linear relationship between the log of the corrosion rate (in mm/year of immersion) and the corrosion potential (E_{corr} in Volts) has been established for cast iron. Corrosion potential becomes increasingly negative with increased water depth, supporting the theory that the corrosion rate is largely determined by the flux of dissolved oxygen. For our homogeneous data, correlation between corrosion potential and water depth is insignificant. However, there is very little variation in water depth over the site and only integer value readings were recorded so that such a comparison is hardly statistically valid. The relevant equation is:

$$\log C = 3.05\, E_{corr} - 0.210$$

where E_{corr} is the corrosion potential in volts and C is the corrosion rate measured in mm / year of immersion (MacLeod, 1989:229). An adjustment (adding 0.070 V to the E_{corr}) can be made to convert the equation into one for wrought iron Using this equation and adjustment and assuming the mean E_{corr} of 0.360V, a prediction that the structure has been corroding at a rate of 0.08mm/year is yielded. This means 0.08mm on each exposed surface, so the width of plating would corrode at twice that rate. Assuming that the wreck has been in seawater for a period of fifty years, this gives a reduced metal thickness of 8mm over that period.

It would be useful to treat data collected over time in a similar way in order to asses the effects of any sacrificial anodes attached.

A Pie Chart illustrating concretion thickness over the specified locations is shown (Figure 8.3), the percentages referring to proportions of locations having certain thicknesses of concretion as opposed to the percentage of a given thickness over the entire wreck.

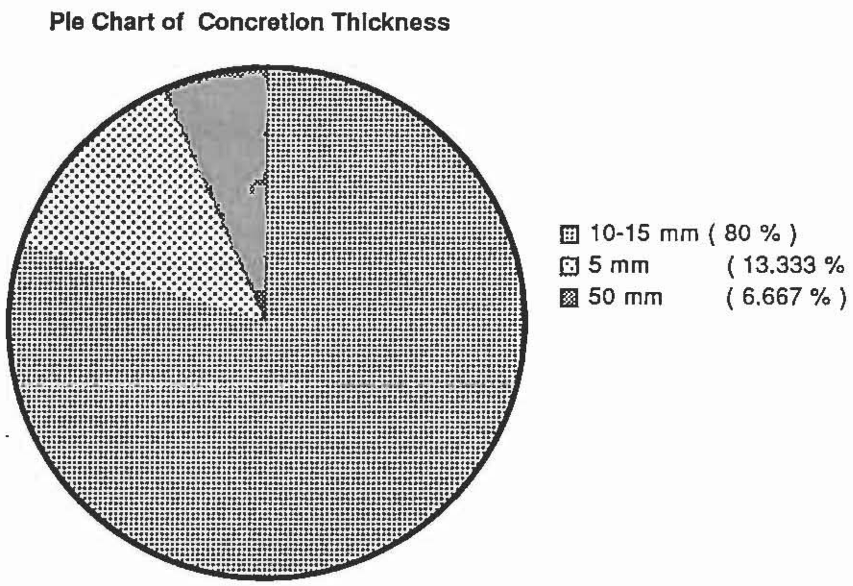


Figure 8.3 Pie-chart of concretion thickness

It could be useful to record the concretion thickness at particular locations for future research purposes although monitoring changes in thickness would be a futile exercise since growth is so phenomenally slow.

To return to the topic of trend analysis, it is proposed that the mean results for each period are inputted onto easily viewed graphs.Trends and sudden changes in trends can then be readily identified. The exact nature of statistical analysis applicable will depend upon the actual measures adopted for on-site conservation of the wreck. If, as it is proposed, a sacrificial anode is attached, some very interesting observations could arise from raw data collected as prescribed. An obvious issue to investigate would be the effect on trend values of the installation. The possible correlation between distance of a particular location from the installed anode and reduction in corrosion potential or rate might yield interesting results.

The precise locations chosen for such a study will depend upon a number of factors (e.g. composition, quantity and location of sacrificial anodes), and until these issues are resolved final locations cannot be determined.

The importance of quality control in the collection of data cannot be too strongly stressed. It has already been seen that a number of technical faults can lead to inaccurate readings. It is vital that a corrosion meter is soaked for at least 20 minutes before stable, reliable results can be assured. The omission of such a step might have been considered as a possible reason for unusual readings obtained and outlined above. However, the fact that results were not changing markedly over time (since collection of data at the 15 locations took well over 20 minutes in its entirety) seems to indicate that this was not a significant factor in this case. To give the diver confidence whilst taking his readings, the use of a simple zinc or similar calibration block in the water would be valuable.

8.3 Conclusion

The conservation management section outlined above is intended to show how the greatest value could be obtained from conservation type activity on the North Mole wreck site. It is also a draft proposal and one that would be modified according to the initial feedback from the ideas contained within it being presented. As such it is not intended to show exactly what would be instigated but rather it has been a way of exploring ideas, techniques and principles that are real and valid.

Preservation of the North Mole Wreck site would be amply justified by a program of this nature.

Conclusion

Despite extensive research, the North Mole dredge remains unidentified and its specific function unconfirmed. Detailed planning of the remains was carried out, allowing further research to be undertaken in the future into the dredge identity.

Future management proposals include public involvement in monitoring the deterioration of the wreck, to further expand iron wreck conservation science.

Appendix I
Biological Survey of the North Mole Wreck.

While the historical value of many ship wreck sites is apparent, their value as a refuge for wildlife is often not considered. The North Mole Wreck site highlights the importance of wrecks as artificial reefs. In an area that was previously relatively void of marine life, the wreck has attracted a wide range of species. Eleven out of the 12 fish species recorded during the survey were reef dwelling species that had used the wreck for habitation. The wreck has clearly attracted a wide range of fauna.

The entire North Mole Wreck is covered with encrusting bryozoans, sponges and tunicates. On the deck this growth is covered with a variety of sea weeds, the dominant species is probably a *Sargassum* .

The outer sides of the wreck exhibit less sea weed, though some kelp (*Ecklonoa*) is present. Large numbers of colonial zooanthids are present, soft corals (probably *Carijoa*) and Sabelliid tubes worms occur in predicted areas.

The interior of the wreck is quite dark and subject to pronounced surge. The variety of sessile growth is less than on exterior surfaces. Again, there is a predominance of encrusting bryozoans, sponges and tunicates, with the stalked ascidian 'sea lily' occurring in large numbers.

Fish observed on the wreck were:

Red striped cardinal fish. *Apogon victoriae*
These grow to a length of about 12 cm, and are reasonably common on coastal reefs. The brownish top reddish stripes along the sides and the black circular blotches on the pectoral and caudal fin bases are diagnostic.

Rough bullseye. *Pempheris klunzingeri.*
These grow to 18 cm in length. Cave dwelling adults are brownish-orange in colour with a darker line down the rear of the head to the pectoral fin base, and are usually pinkish-brown when in the open.

Banded sweep. *Scorpis georgianus*
These grow to a length of 35 cm and are common over in shore and off shore reefs, preferring shallower waters. The black crossbands on the body are distinctive.

Stripey. ***Microcanthus strigatus***
These grow to a length of 50 cm, and are found on shallow protected reefs. They are easily identified by the characteristic yellow and blackish stripes.

Western buffalo bream. ***Kyphosus cornelii***
These grow to a length of 60 cm and are common on shallow reefs. The caudal fin is slender and forked, with a brownish stripe on the upper and lower portions. They are wary of divers and easily frightened.

Truncate coral fish. ***Chelmonops truncatus***
These grow to a length of 25 cm, and are frequently observed on coastal reefs. they are best identified by the pointed snout and the four to five blackish bands on the sides.

Crested morwong. ***Chilodachylus gibbosus***
These grow to be 30 cm, and are found on shallow protected reefs. The colour pattern is diagnostic with oblique black stripes.

Common scalyfish. ***Parma mccullochi***
These grow to a length of 25 cm, and are very abundant in all reef areas. The small juvenile is very colourful, being mostly bright yellow with a pattern of iridescent blue spots and stripes on its head and body. As it increases in size it turns a drab brown in colour.

Sea carp. ***Dactylosargus arctidens***
These grow to 40 cm in length. The blunt, cockatoo like snout and colour pattern are distinctive.

White-barred boxfish. ***Anoplocapros lenticularis***
These grow to about 25 cm in length. The adult is orange to red with characteristic white bars, whereas the juvenile is yellow with brown irregular stripes on the head and body in addition to the white bars.

Red gurnard. ***Chelidonichthys kumu***

These grow to a length of 55 cm. members of this family have large, wing-like pectoral fins. Preceding this fin are three detached rays in the form of feelers which are used for walking on the bottom and turning over small rocks in search for food.

Samson fish. ***Seriola hippos***

These grow to a length of 150 cm and 45 kg in weight. They are usually silver to silver grey and occasionally have a yellowish line on the side.

APPENDIX II

North Mole C.P. and p.H. survey pro-forma sheet.

North Mole marine growth survey pro-forma sheet.

Wreck divers passport, outside page (folded into three in practise).

Wreck divers passport, inside page (folded into three in practise).

CORROSION POTENTIAL MEASUREMENT SHEET

NORTH MOLE WRECK SITE

DATE:

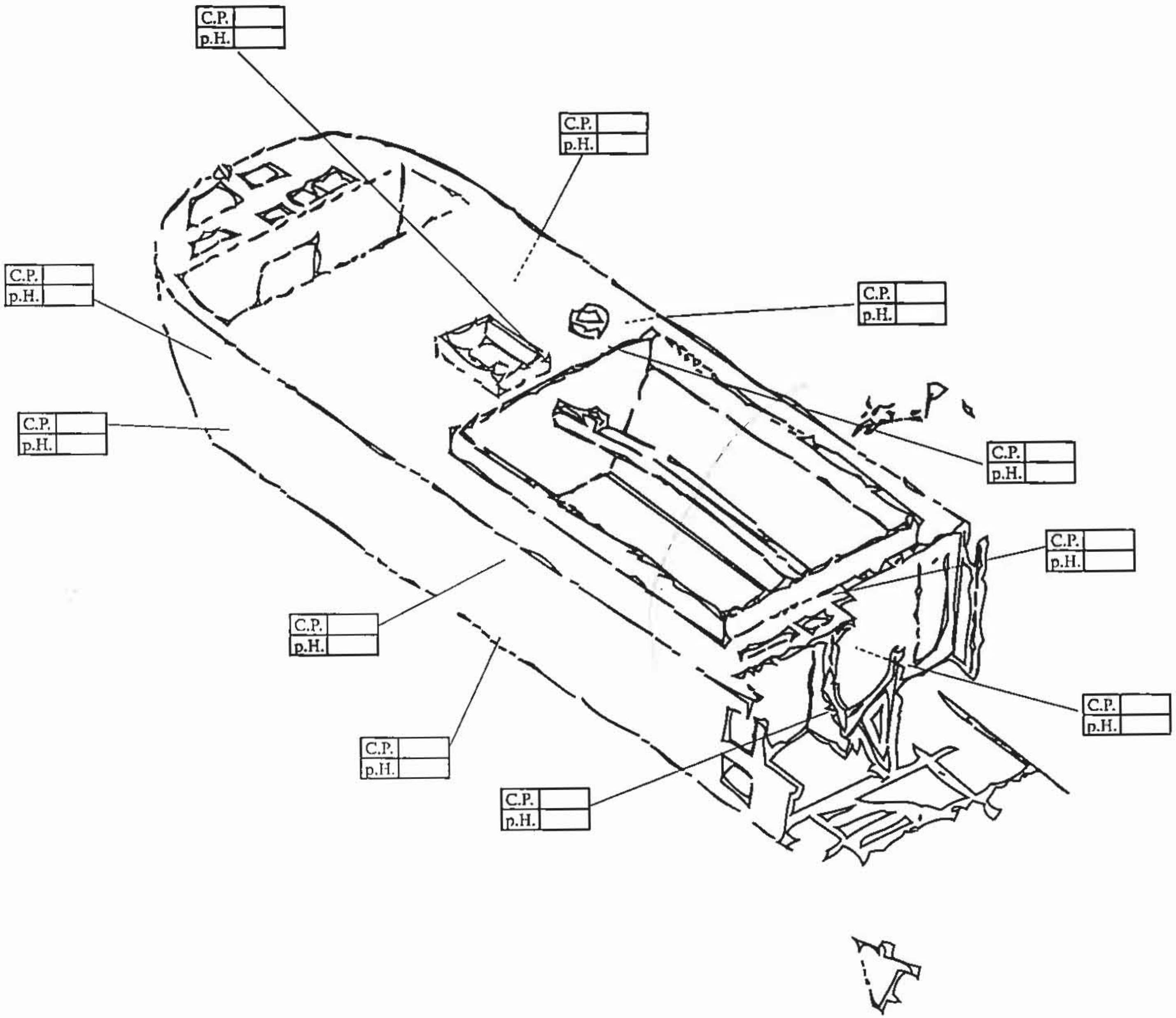
DIVER:

CALIBRATION READING:
ZINC BLOCK:
LEAD WEIGHT:
LABORATORY:

TEMPERATURE:

METER TYPE :
MUSEUM ☐
PROXIMITY PROBE ☐
BATHYCORROMETER ☐

NB. C.P. readings should be taken at the tip of the installed measurement point only.
p.H. readings must be taken by drilling a new hole in the concretion in close proximity to the C.P. point. Do not use a hole drilled in a previous year.
Meters must be soaked in sea water for 30 mins before use.
Meters must have calibration check in water prior to readings being taken.



Western Australian Maritime Museum 1990

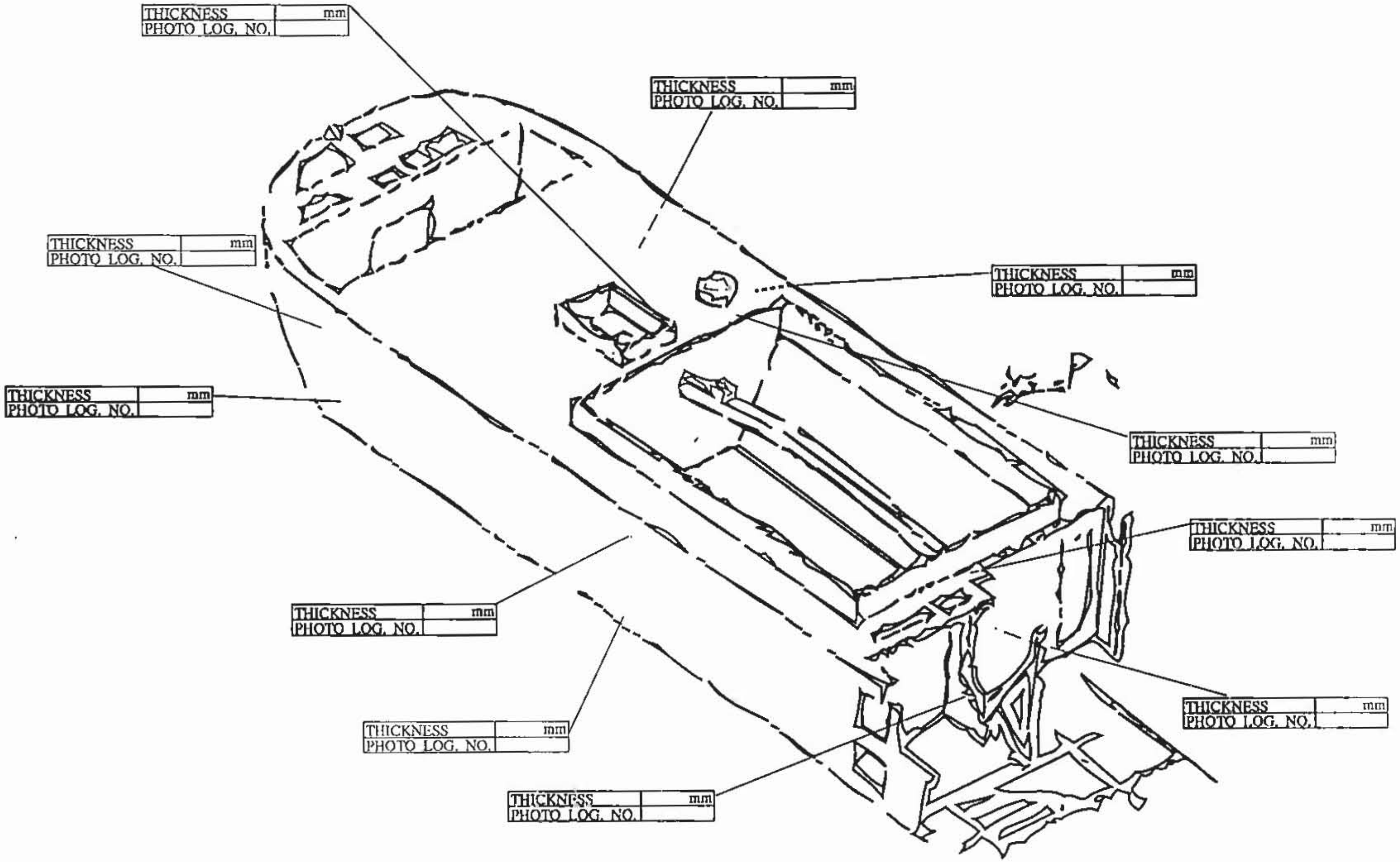
MARINE GROWTH SURVEY

NORTH MOLE WRECK SITE

DATE:

DIVER:

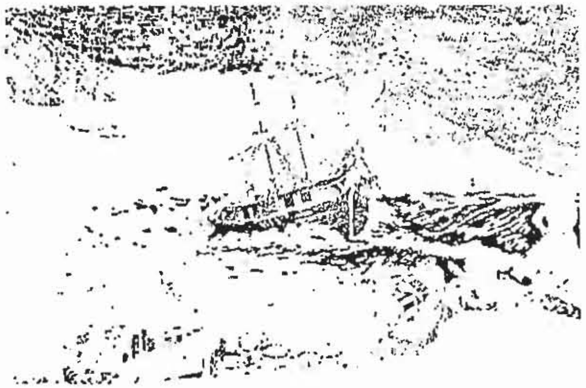
NB. When inspecting marine growth levels in each location, make the assessment on a representative area of approximately one square metre adjacent to that area. Take a colour slide photograph of the area examined to allow comparative analysis. When measuring marine growth thickness use only the museum supplied guage.



Western Australian Maritime museum

1990

The Wreck Diver's Passport is a way for all Divers to participate in maritime archaeology.
If you undertake this scheme and dive these wrecks with designated dive boats, schools, clubs, and shops, they can sign and stamp it up. When completed, you can apply to participate in maritime archaeology schemes that are currently underway at Fremantle, through the local Maritime Archaeological Association.
Wreck diving is fun and exciting and there is much to learn from our shipwrecks.
They are part of our heritage and culture. Look after them so that they will be a source of excitement for future generations.

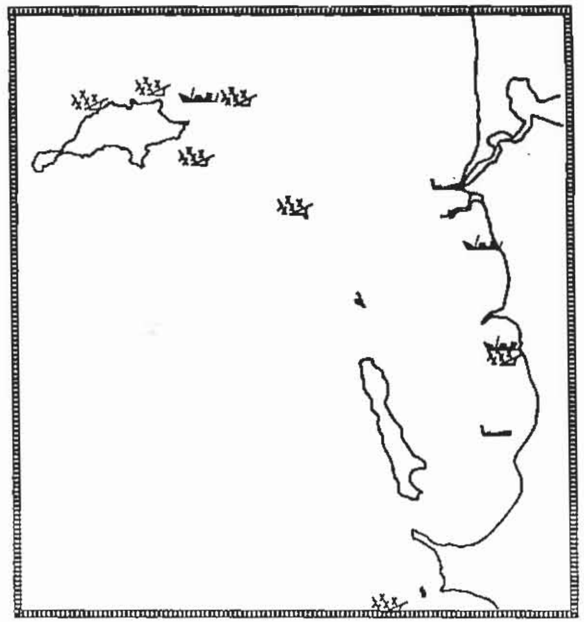


Details of the Fremantle Wreck Trail are available at The W.A Maritime Museum, information bureaus and dive shops. You will find histories, positions and information to assist in organising dives.

Western Australian Maritime museum

WRECK DIVERS PASSPORT

Western Australian Maritime museum



SHIPWRECKS	THEIR HISTORY	Signature	Stamp
ALACRITY	French built twin screw 353 ton iron steamer that worked towing barges to Henderson naval base during construction. She washed ashore on her way to breakers.		
ABEMAMA	The three masted wooden schooner now lies just 10 mtrs from the Abemama. She ran aground in a gale and later caught fire burning to the water line in June 1927.		
CARLISLE CASTLE	Iron ship lost 1899 with all hands, in same storm as the City of York. She carried general cargo for Fremantle but perished on Coventry reef.		
CITY OF YORK	Glasgow built iron barque lost when its captain mistook the Rottnest light for another ship in fog. Eleven souls perished that night in July 1899 and the disaster led to various navigation improvements.		
D 9	Formerly the Fremantle built, 1930s bucket dredge, 'Parmelia' she was converted into a suction dredge for channel excavation at Kwinana. She sank as recently as 1962.		
DENTON HOLME	Formerly 'Star of Denmark' she now lies on top of Macedon. An iron barque of 998 tons she carried water pipes and general cargo from Glagow before wrecking in September 1890.		
JAMES SERVICE	Iron three masted barque bound for Melbourne from Calcutta. Wrecked on Murray reef in 1878 with all hands lost. The sad story of storms was only known from a diary found on Mandurah beach.		
LADY ELIZABETH	One man died when she struck a reef near Dyer Island on the Night of July 30 1878. She had turned back from her voyage from Fremantle to Shanghi with Sandlewood due to storms.		
MACEDON	Iron steamer, 67mtr , 876 tons, Liverpool built 1870. Whilst towing a boat to Rottnest on 21 March 1883 she was stranded with 50 passengers, horses, mail, specie and general cargo. No lives lost.		
NORTH MOLE	Unidentified wreck of a barge like those used to transport spoil dredged by steam grabs. Moved by heavy crane during harbour extension in 1988 to save an excellent site for novice divers.		
OMEO	Ran aground as a hulk from Owen anchorage after former career as steamer then sailer. Once layed the telegraph cable from Darwin to Adelaide.		
ULIDIA	1378 ton iron barque lost after bringing rails for the Albany Fremantle line from Barrow in 1893. Her anchors dragged and failed to save her from a storm. She struck the stragglers and sank.		
LONG JETTY	Not a shipwreck as such but the site of Fremantle's original harbour facilities, making it full of the debris of Australia's early shipping.		

Appendix III

Proposed popular article concerning the moving of the North Mole Barge

On the morning of Wednesday 16 November 1988, the locally popular dive-site known as the 'North Mole barge' was moved, as per Western Australian Museum (WAM) proposals and with Fremantle Port Authority (FPA) funds, from its former position within an area due to become a new commercial harbour to a nearby location with easy diver access. It was saved for the diving community who would otherwise have lost access to the wreck which did not fall under protective legislation.

The natural population expansion of a thriving state such as Western Australia posed the government with the problem of how to expand Fremantle Port facilities in the least environmentally damaging way possible whilst still ensuring its future status as a front line international container port. The proposal finally accepted as a solution was named "Project Seafreight 2000". It had three essential elements:

(1) dredging the Inner Harbour to provide for larger container ships

(2) using the spoil to create 30 hectares of industrial land north of the harbour's North Mole. The reclaimed land was to be called Rouse Head.

(3) providing a new harbour (Rouse Head Harbour) within the reclaimed area for small commercial vessels

The new industrial land and harbour would solve another goverment problem. The State Government's superannuation fund had invested in an area of industrial land, used by local companies and bordering the Swan River (in the mouth of which lies Fremantle Inner Harbour). The fund proposed to build a marina development with offices overlooking mooring berths. The land removal necessary would mean the displacement of a number of firms' premises (including those of Rolly Tasker's famous sailmaking company). The government, therefore, saw the land reclamation proposal as an opprtunity to offer those displaced companies alternative accommodation with harbour facilities close at hand.

The area proposed for reclamation , immediately north of the North Mole, had been used as a dumping ground and breaking yard for damaged, unseaworthy and unprofitable vessels for some eighty years. The resultant wreck sites were well-known by the local diving community and dived on regularly. The amateur Maritime Archaeology Association of Western Australia (MAAWA) and its mentor, the Maritime Archaeology Department of the WAM were well aware of the richness of the area and not only of its importance to the maritime history of the port but also as an invaluable educational and recreational asset to the community. When details of Project Seafreight 2000 became known the Maritime Archaeology Department of the WAM became particularly concerned about the future of one of the most popular wrecks. The "North Mole Barge", renowned as a great training dive with easy access, lay just 100 metres off the North Mole within the proposed area of Rouse Head Harbour and the community was in grave danger of losing that access. Since it lay in State waters and was reckoned to have been lost post 1900, the wreck could not be protected under current legislation. Moving the barge was considered risky - it might fall apart.

In March 1988, Mike McCarthy, Inspector of Wrecks at the WAM and think-tank behind the Museum's popular Rottnest dive-trail, strongly believing in the importance of the recreational aspect, proposed an exchange to be undertaken in conjunction with the FPA i.e. to sink another derelict barge in an area of equally easy diver access on the seaward side of the new harbour wall. Whilst the FPA agreed to this proposal and also to fund MAAWA's preparation of a booklet about the wrecks in the area, a suitable alternative barge was not found in time. In September 1988 construction of the new harbour wall started. So it was that the previously rejected idea of moving the barge seemed the only possibility for its continued use. Careful consideration was given to the problem and how to eliminate as much risk as possible.

On 16 November the *Pelican*, an FPA 80-ton swim-end floating crane built during World War II, did the lifting. The *Pelican* is steam-run with a very smooth lifting power and its platform has to be both pushed and towed by tugs as it has no propulsion system of its own. By using carefully positioned slings the barge was raised to the surface and then towed to its new resting place . The move was highly successful bar one hitch: the boiler fell through the bottom of the hull *en route* . It might be argued by non-divers that this was something of a bonus for them since the locomotive-type boiler was retrieved and now stands on display at No.1 berth, Fremantle Inner Harbour.

The 'North Mole Barge' now lies 190 metres from the North Mole lighthouse on a bearing of 40°. It is a fascinating dive with most of the barge intact and thriving marine life. Schools of wide-eyed fish greet you as you enter the hold after swimming over the sponge and soft coral-covered deck. It is now as popular as ever, testimony to the success of the combined Western Australian Museum (Maritime Archaeology Department) and Fremantle Port Authority initiative.

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