THE HAMELIN BAY, JERVOISE BAY AND MANDURAH SHIPWRECKS

A field exercise linking wreck site archaeological research
With wreck trail promotion

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INTRODUCTION

This is a two part study. The first part deals with specifically archaeological issues and the second with issues of wreck site management. These matters are inextricably related. Wreck site management maintains and protects the history that a site represents. In varying degrees it enables the more important archeological work to take place by this protection.

Archaeology may require urgent preservation of wreck sites as they stand. For example, the *William Salthouse* site in Port Phillip Bay, Victoria has recently been subject to a most substantial program to stabilise its condition[1]. Whilst many wrecks will not warrant such substantial effort and expenditure all historic shipwreck sites require a degree of management to maintain them and the history that they hold.

To preserve sites effectively, a full understanding of what a site comprises is required. This of course comes from the various surveys that maritime archaeologists conduct on each site. However, in addition to this, an understanding of how a site reached its current status is also important.

This aspect of our work does not always receive the foremost attention. The history that the wreck contains, developed through examination of artifacts and vessel remains, generally and correctly takes precedence. However, understanding the way in which a wreck degraded, and ultimately came perhaps to be no more than a pile of stones and concretion, is a vital tool to our work. Understanding how different wrecks in different conditions degrade enables us to have a clearer idea where artifacts may be held within a specific wreck and how much of a vessel might remain beneath the surface of a site.

Developing this understanding is therefore the archaeological intention of this study. It may be perhaps an introduction for further and more detailed study but his does not diminish its value.

It is unfortunate that owing to personal circumstances some of the work has been of a stop and start nature. The necessity to conduct foreign travel in the midst of a substantial project has been a considerable distraction. Despite this, aims for the project were outlined at the start and every effort has been made to fulfil them. These aims stem from the desire to develop the understanding outlined above and are broadly based.

Given the unusual personal circumstances it has been possible to combine the research with a related practical museum program. This program concerns wreck site management. It is related because historic sites must be preserved to protect the history that they hold and represent.

In section one the wreck site degradation research has a distinct starting point. This is the theory that has been put forward by John Riley in his 'Water-line Theory of Iron Ship Disintegration,'[2]. This is specifically a study of iron wrecks that lie on sand. However, the intention of this study is not limited to this one category. It is to examine a number of differing wrecks in the locality and see if wrecks of other construction or seabed type also correspond to his ideas. The examination of local wreck sites is backed up by references to other sources and other sites that most clearly demonstrate the issues raised.

Section two describes the work that has been conducted on wreck site management. By its very nature this work is largely practical though many disciplines have had to be employed to execute the work.

Certain goals were set for this section and they mainly entailed the development of wreck trail schemes for Mandurah and Hamelin Bay. Achieving these and conducting the research and survey work necessary for section one would require many differing activities including;

> Archival research, writing texts for display plaques, reconnoitring and photographing potential plaque sites, both underwater and on the foreshore, planning and executing diving activities, surveying wreck sites, logistical organisation of personnel, construction equipment and transport, acquisition of materials, learning museum administration procedure, liaison with other involved government bodies and officers, budgetary control, costings, locating suitable suppliers of many goods and services, desktop publishing, drawings, artwork construction and layout, and a number of other activities.

The wreck site research would to an extent be dependent on the sites that were readily available to visit. The Hamelin Bay sites being at some distance proved impractical and too costly to involve in the site research element. Despite the interesting material these sites represented, this was thought to be financially prudent as more local sites could be substituted. Thus, a number of sites in the Jervoise Bay area were used.

The research was specifically intended to develop an understanding of wreck degradation in a variety of differing environments. The wrecks that were examined were therefore categorised into construction and seabed type, producing the four groups of iron on sand, iron on reef, wooden on sand and wooden on reef.

The choice of field work assignment was influenced by other themes that were developed during the graduate diploma work. In particular, work involving the conservation of iron shipwreck sites, promotion of wreck trails and wreck site management,. The Conservation Report on the *Sepia* site, the popular magazine article 'Dive The Fremantle Wreck Trail', and the potential A.I.M.A. Bulletin article on a new design of wreck trail plinth, are all related studies. These reports are included in the appendices for reference.

Much of the work that has been expended in section two of this assignment has gone into the creation of plaques and brochures. Whilst copies of these have been supplied they are the only representation of considerable amounts of work. Desk top publishing programs have had to be mastered, government procedures understood and many diverse tasks assembled to produce what may appear to be modest results.

Finally, it should be noted that the Mandurah and Hamelin Bay Wreck Trail Projects are on going and work will continue to be undertaken after this assignment has been marked. Therefore a projected timetable up to completion date has been included in appendix I. The archaeological research element may well be continued later on within other institutions.

SECTION ONE

WRECK SITE SURVEY AND RESEARCH

This study considers the ' The Water-line Theory of Iron Ship Disintegration,' as formulated by John Riley for consideration of iron shipwrecks on sand. Whilst Riley examined over 100 iron and steel wrecks around the New South Wales Coast, this work also considers the implications of this theory when applied to other categories of wreck site. In particular, a comparison of four broad site types is made. These are;

Iron wrecks on sand
Wooden wrecks on sand
Iron wrecks on reef
Wooden wrecks on reef.

The underwater environment is as diverse in the way it influences what lies amongst it, as any that may be found on the surface of the earth. Whether a dry desert or a barren ice cap the sea and seabed are just as unique in the way it effects whatever is placed in it.

Shipwrecks are accidental (in most cases) intrusions of a mass from one physical arena arriving in another. Whilst ships are built to operate on the surface of the sea they are not built to survive perhaps hundreds of years at the mercy of the underwater world.

There are many aspects of the environment that will effect the way in which a shipwreck degrades. They are both physical and chemical and they interact with each other in a complex form, unique to the prevailing conditions on each individual site. Despite this, it is possible to distinguish groups where different sites are similar to others. The four types which are compared are a most simple categorisation and within them there would be many other divisions. For example, if a wider geographical spread were to take place then considerations of temperature would be essential.

THE WATER-LINE THEORY.

The water-line theory of wreck disintegration puts forward a clear interpretation of the progressive degradation of iron shipwrecks on sand. To enable a comparative study of other site types should be clear what it says.

As is suggested by its name the theory proposes that on the seabed the wreck sinks into the sand to about the level of the usual hull water-line. In this way the interface between water and air is mimicked by that between water and sand. Seasonal sand shifts may occur but the position of the wreck remains unchanged until its structure starts to degrade. The dynamic effects that the sea imposes coupled with the ravages of corrosion will mean the structure will loose its strength. The deck and deck beams collapse and are followed by the hull sides, unless supported by the bulkheads.

Other areas of high structural strength also remain such as the bow and stern, the heavy machinery, engines and boilers. Where these are attached to weaker plates they will eventually fall off or through them due to their weight. They can then settle and support the other remains in a fixed position. Some items may move around. The predominant feature of many steam ship wreck sites is the boiler and engines. Sometimes the action of surge can tip a boiler onto its front or rear. This will expose the less resistant curved sides of the boiler to the surge and the boiler will often then remain in that position.

Sand will often accumulate and fill the inside of the hull, again to the water-line level with the remaining hull becoming a tub where artifacts fall and are held. When the wreck has reached this point its degradation has slowed down greatly. It is no longer subject to such dynamic force due to its much lower profile and as Riley points out, only divers and the occasional boat anchor then do any immediate damage to what has become an oasis in the sand, where marine life abounds.

A number of specific examples are discussed by Riley and a clear picture develops of shipwrecks sinking into the sand to the water-line. They are then damaged by dynamic forces until only their strongest features remain.

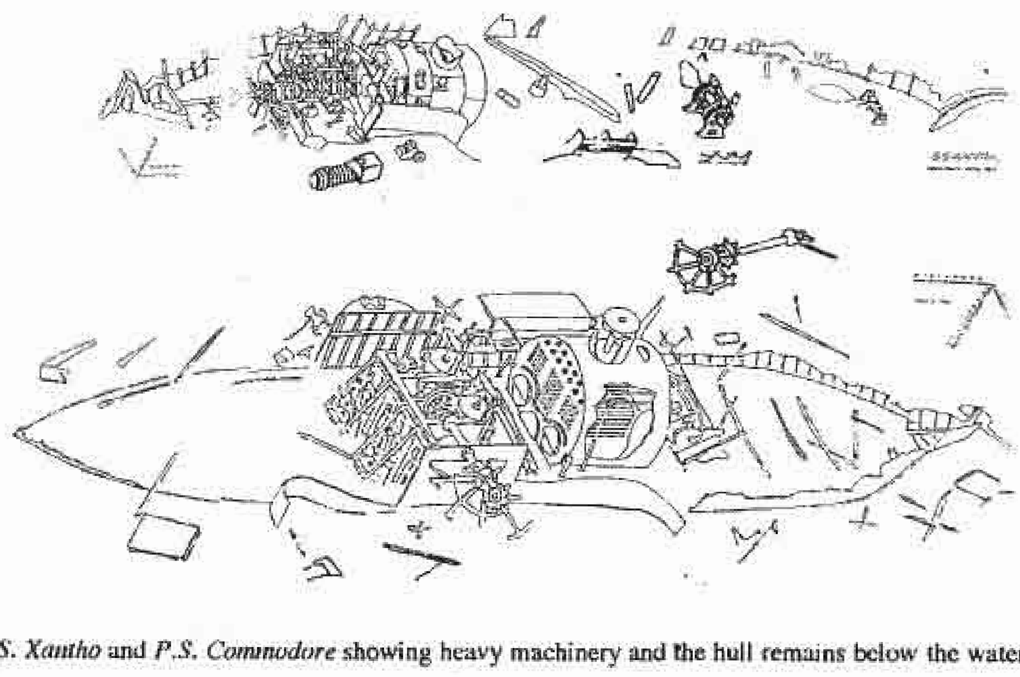


Figure 1. *P.S. Xantho* and *P.S. Commodore* showing heavy machinery and the hull remains below the water-line [3].

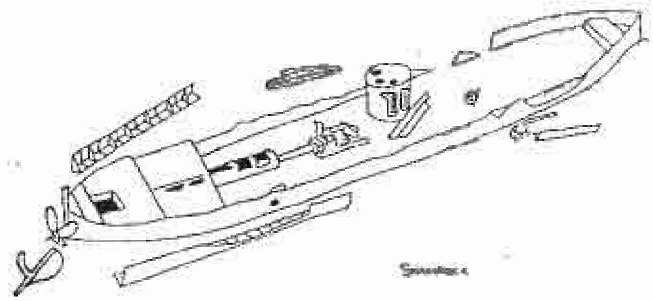


Figure 2. The *S.S. Shamrock* showing boiler tipped on its side to form least resistance.

Figure 2a. The boiler of the *S.S. Windsor*, tipped up an Abrolhos shallow and showing the effect well.

SURVEYS OF MANDURAH AND JERVOISE BAY WRECK SITES.

Originally the proposed sites were as follows:

MANDURAH	*James Service*, (1878).	Iron vessel, on reef.
	Highland Forest, (1901).	Iron barque, on reef.
	Star, (1878).	Wooden schooner, on reef.
	Chalmers, (1874).	Wood barque, on reef.
HAMELIN BAY	*Katinka*, (1900).	Iron barque, on sand.
	Agincourt, (1882).	Wooden barque,on sand.
	Chaudiere, (1883)	Wood composite, on sand.
	These vessels were built in the same yard, are wrecked close to each other but have differing orientation to the sea.	

Owing to the operational constraints outlined in the introduction the following sites were examined leaving the reminder for further research.

MANDURAH	*James Service*, (1878).	Iron vessel, on reef.
	Highland Forest, (1901).	Iron barque, on reef.
	Star, (1878).	Wooden schooner, on reef.
	Chalmers, (1874).	Wood barque, on reef.
	James Service, (1878).	Iron barque, on reef.
JERVOISE BAY	*Alacrity*, (1931).	Iron steam tug, on sand.
	Abemama, (1927).	Wooden schooner, on sand.
	Omeo, (1900).	Iron barque rigged steamer, on sand.
	Diana, (1830).	Wooden brig, on sand.
	Jame, (1878).	Wooden barque, on sand.

THE FIELD SURVEYS

The wrecks that are examined within this field work assignment are not limited to iron or steel on sand. The purpose of this particular study is to examine the possibilities that exist for the theory to be applied to other environments. Wooden wrecks are examined to see if they fit in any way with the model and differing wrecks on reef are also examined. Each wreck is taken in turn, and site observations and previous studies considered, to assess whether the model fits or relates to the site.

IRON VESSELS LYING ON SAND

ALACRITY

This 145 feet long, twin screw tug, first came into use in Fremantle in 1902. It is perhaps better remembered in its use by the navy. During World War One it was used as an unarmed patrol vessel for the Indian Ocean and as a harbour tug. Following the war she was involved in the ultimately abortive Henderson Naval Base that fell to the cuts imposed during a period of disarmament. *Alactrity* was therefore put up for disposal along with other plant from the abandoned Henderson base by Cabinet decision in 1925. Under new owners she operated for 6 more years before being sold for scrap. Whilst awaiting the cutting torches she broke from her moorings in Jervoise Bay and ran aground to the spot where she exists today. When construction of the oil rig Ocean Endeavour took place the coastal topography changed and whereas she was once a clearly visible feature of the beach she is now lying in three metres of water.[4]

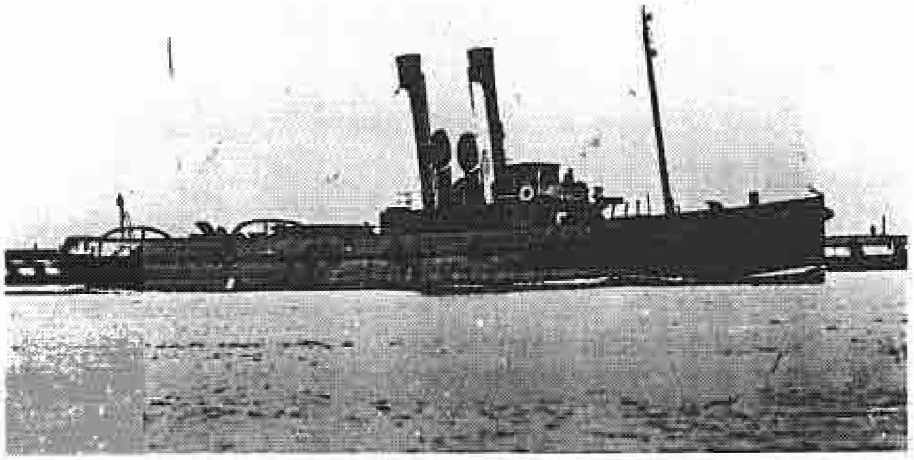


Figure 3. The *Alacrity* at work.

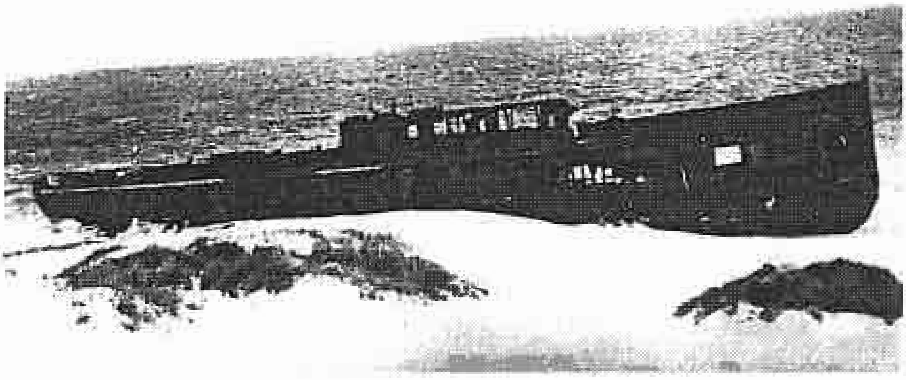


Figure 4. The *Alacrity*, having been beached for some time.

Figure 5. The *Alacrity*, further degraded with *Abemama* in foreground.

Figure 6. The *Alacrity*, as the coastal changes take effect.

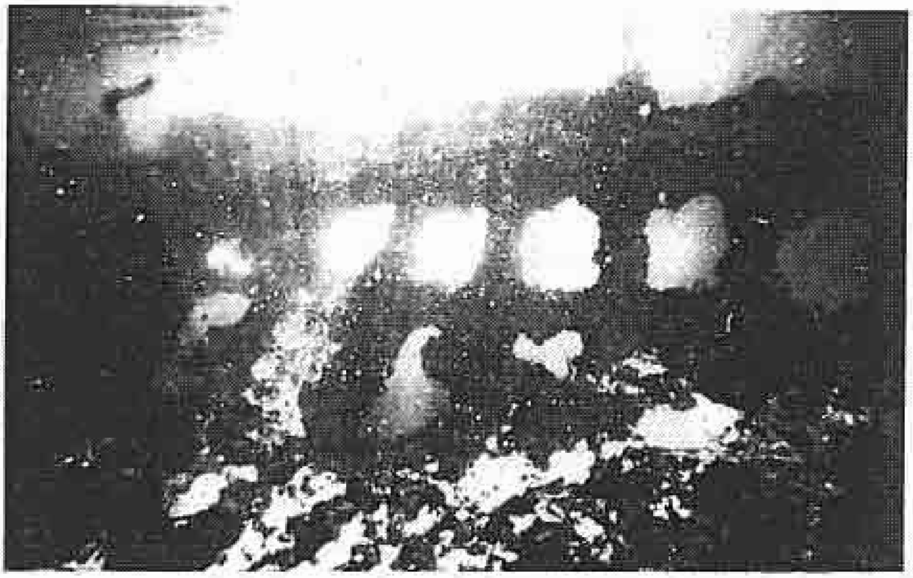


Figure 7. The *Alacrity*, now submerged, showing ribs above the turn of the bilge.

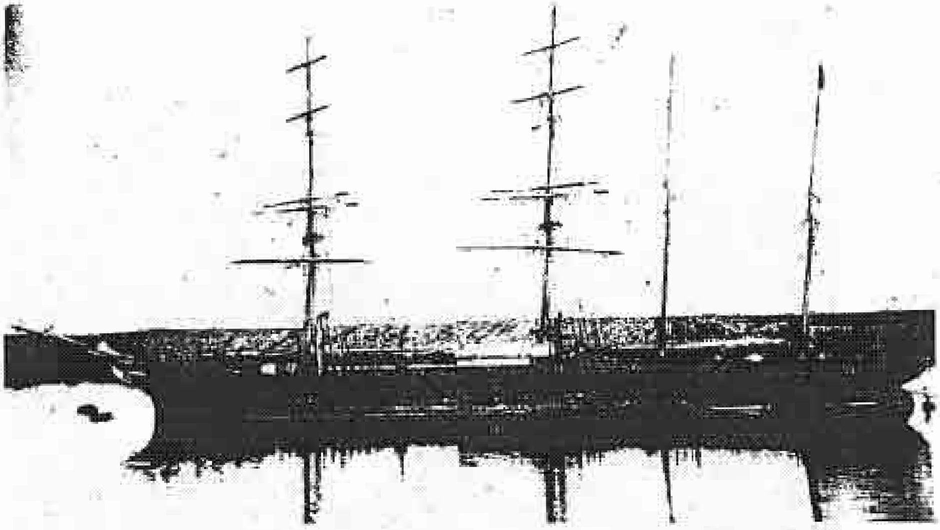
Having lasted remarkably well in its beached position the past years have resulted in considerable further deterioration. However, whilst many of its plates have now collapsed around the turn of the bilge, and the wreck is a beached wreck, there are a number of features where the wreck coincides with the Riley model. The bow and stern remain upright and distinguishable. Also and most noticeably, several major bulkheads are in place forming support for the adjacent ribs and pate work.

It is therefore reasonable to state, that despite the long period when it deteriorated in a beach environment, the *Alacrity* is finally degrading in the ways that Riley has suggested. Whilst beached the *Alacrity* appeared to an extent to have sunk to the approximate water-line as shown in figure 5. Early salvage of heavy machinery will effect the final degradation it undergoes underwater.

OMEO

This 789 ton vessel was built in 1853 of iron with a barque rig. During her life she had been carrying telegraph poles up river for the Darwin to Port Augusta link. More latterly she was hulked in the Jervoise Bay area and suffered the typical fate of blowing ashore in a gale. Beaching at Coogee in 1900 with 500 loads of timber aboard she has lain in this location ever since in just a few metres of water.

The vessel has degraded over a long period of time and a series of photographs have been compiled to demonstrate the clear process involved.



Figures 8. The *Omeo*, whilst loading.

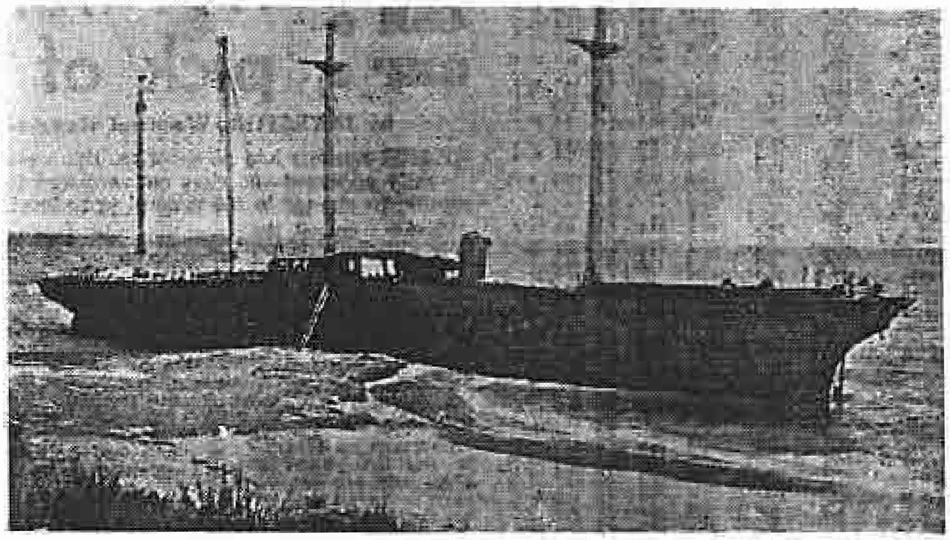


Figure 9. The *Omeo*, beached with back broken.

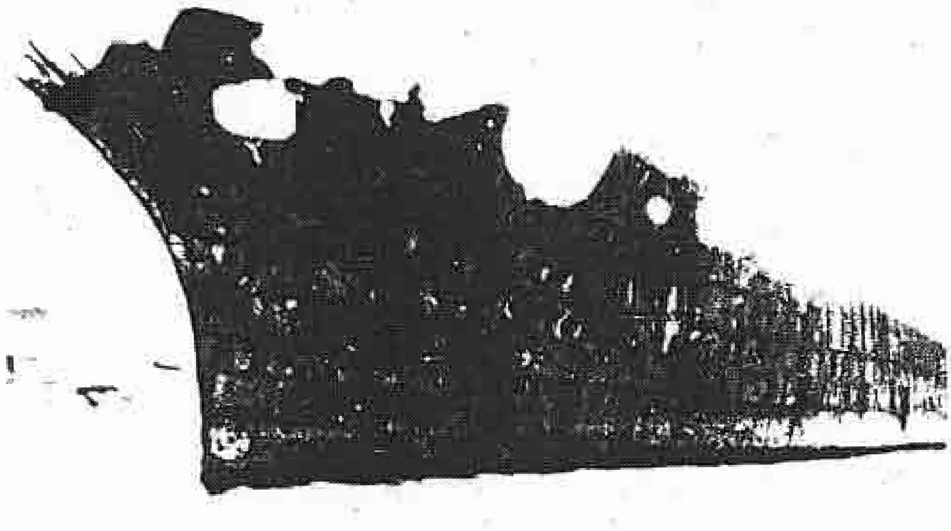


Figure 10. The *Omeo*, steadily degrading.

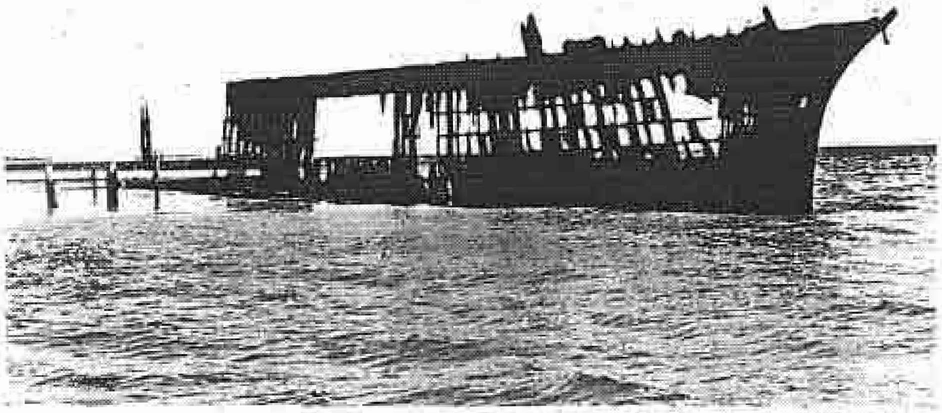


Figure 11. The stronger areas, such as the bow, withstand weathering the best.

Figure 12. The vessel largely as she is today.

Examination of the site reveals considerable remains below water as well as areas above. Those projecting areas are associated with parts that have additional structural strength, most notably, the bow, which whilst having fallen over, has substantial remains on the port side.

Most of the hull sides are collapsed from the turn of the bilge upwards and noticeably the interior of the hull contained only limited quantities of sand. One can only presume that the prevailing conditions have flushed out the interior. As the winter season has only recently ended it would be interesting to see the state of the hull's interior in March, after the summer conditions have built up beaches.

WOODEN VESSELS LYING ON SAND

ABEMAMA

The remains of this 133 foot long wooden schooner lie close to those of the *Alacrity* which is 8 metres or so to the west. In 1927, she was in generally poor shape, despite being less than ten years old. At anchor, near the *Alacrity* in Jervoise Bay, she suffered the ravages of a severe storm and was beached. A few weeks later she was burned to the water-line by vandals. The practise of burning condemned hulks to obtain their copper fastenings means that there are a number of wrecks that remain in a similar condition to this one.

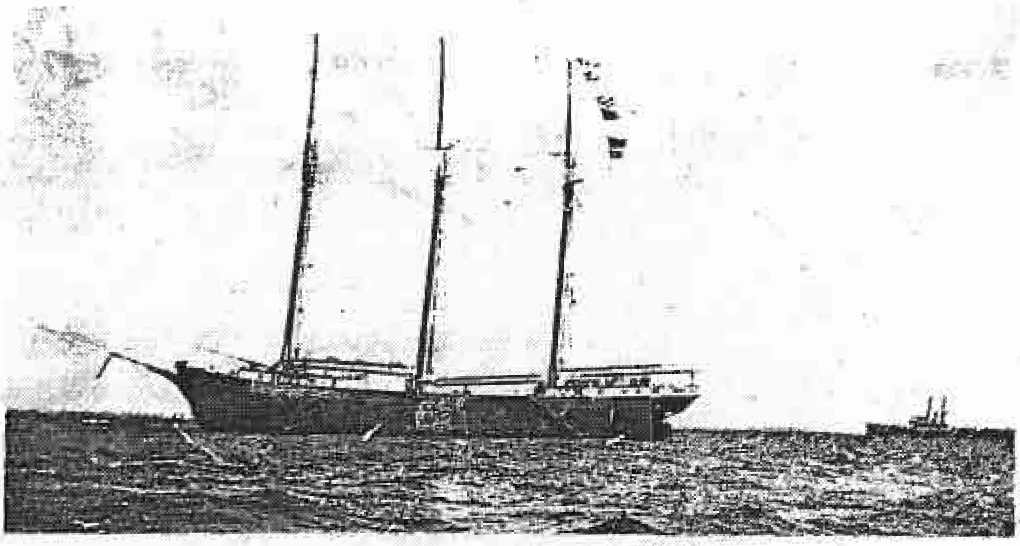


Figure 13. The *Abemama*, lying at anchor[5].

Figure 14,
The *Abemama*, beached[6].

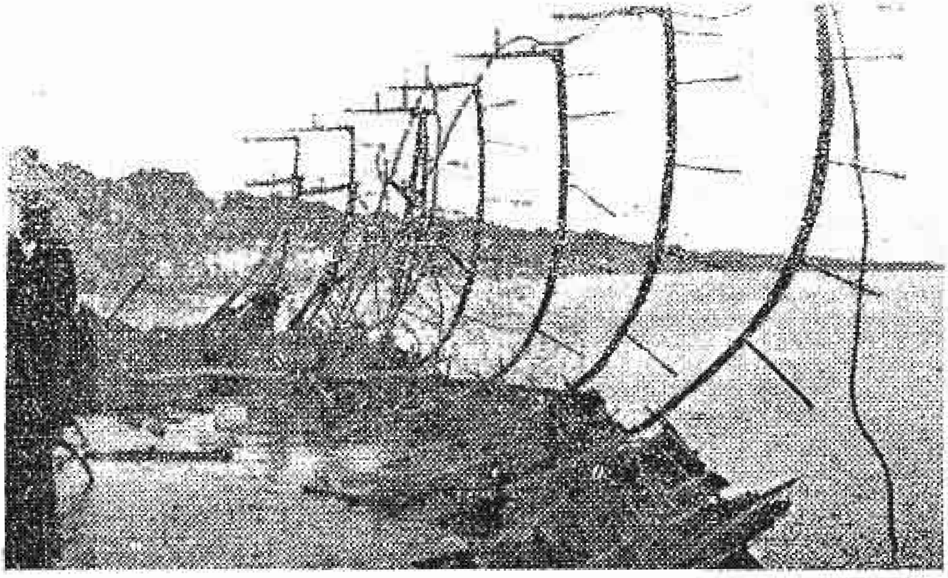


Figure 15. The *Abemama*, having been burned[7].

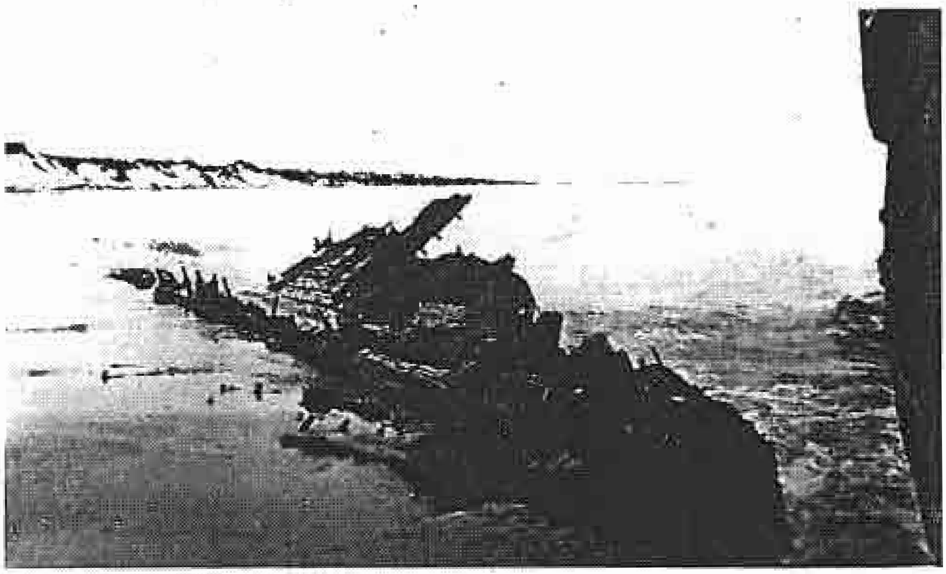


Figure 16. Adjacent to the *Alacrity*, the *Abemama* timbers, the iron knees no longer present.

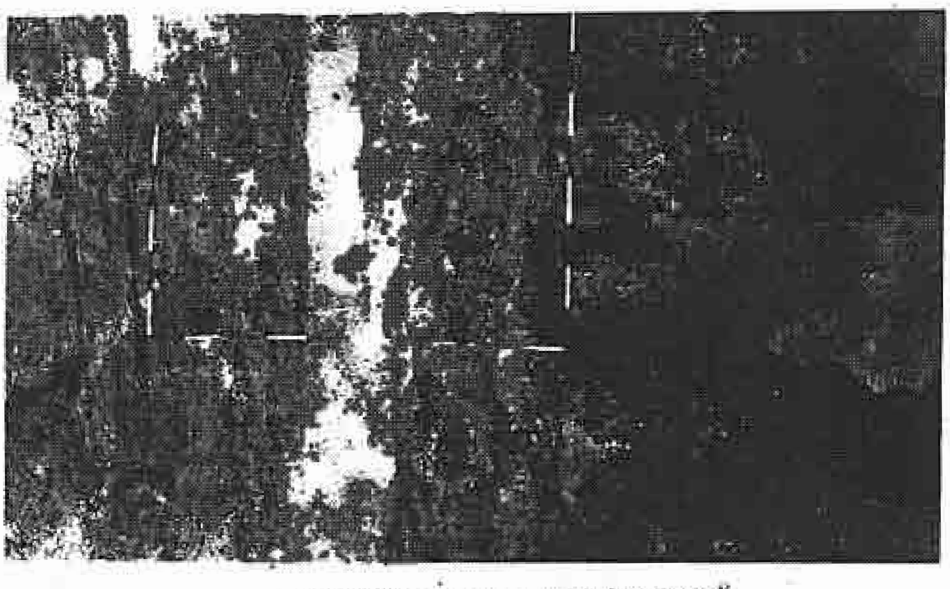


Figure 17. Exposed ribs of the *Abemama*, as can be seen underwater today[8].

The *Abemama's* remains were to an extent protected by sands until the construction site changed the coastline. This submerged the site and resulted in greater exposure of the materials allowing survey work to be conducted. The remains make an interesting study but it should be remembered that the degradation commenced with the fire. Thus the timbers have been largely denuded before immersion.

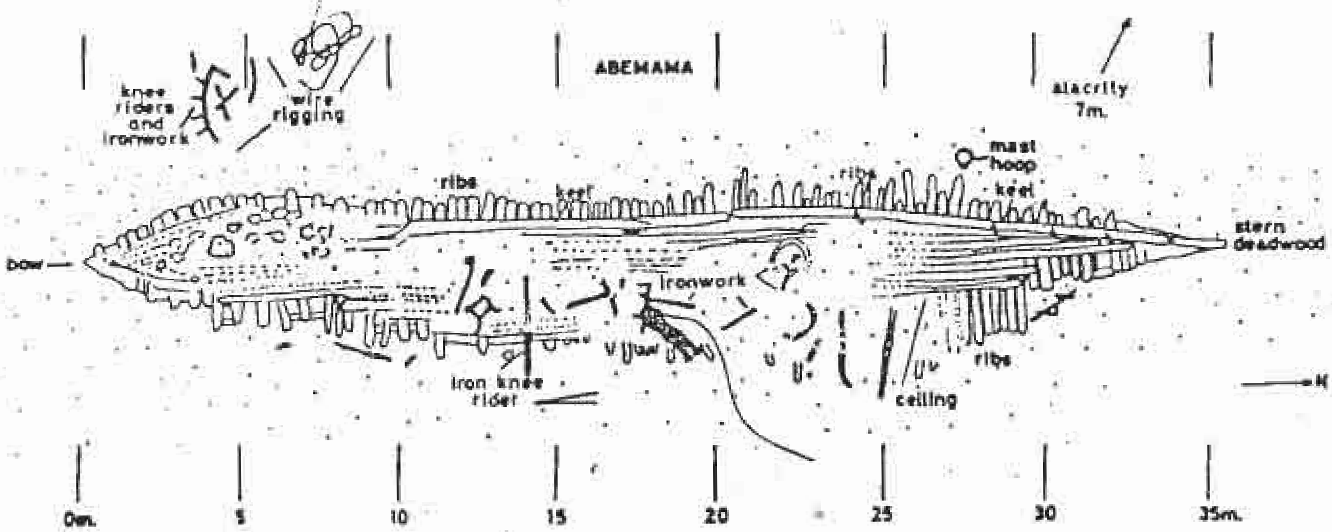


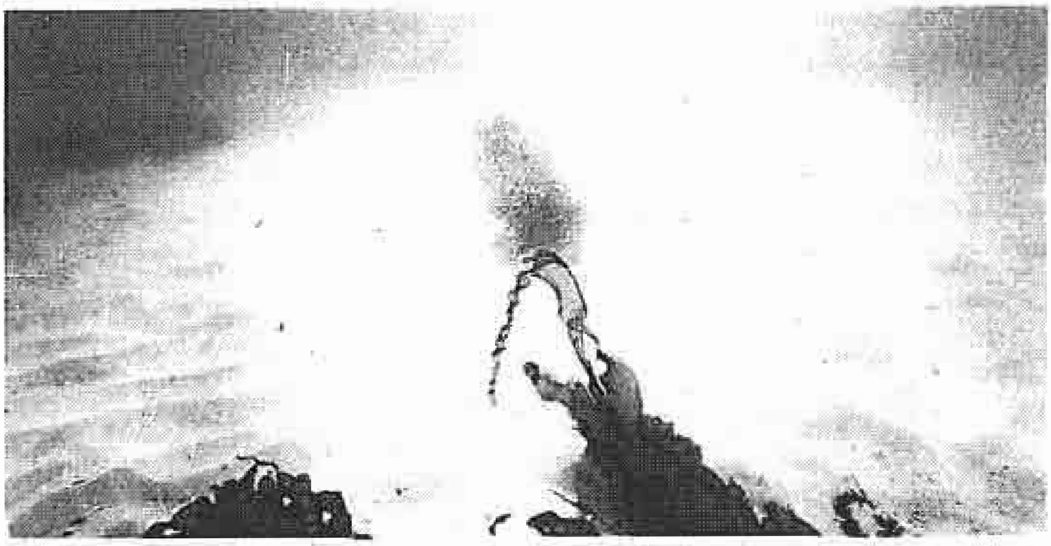
Figure 18. Drawing of the *Abemama* wreck site[9].

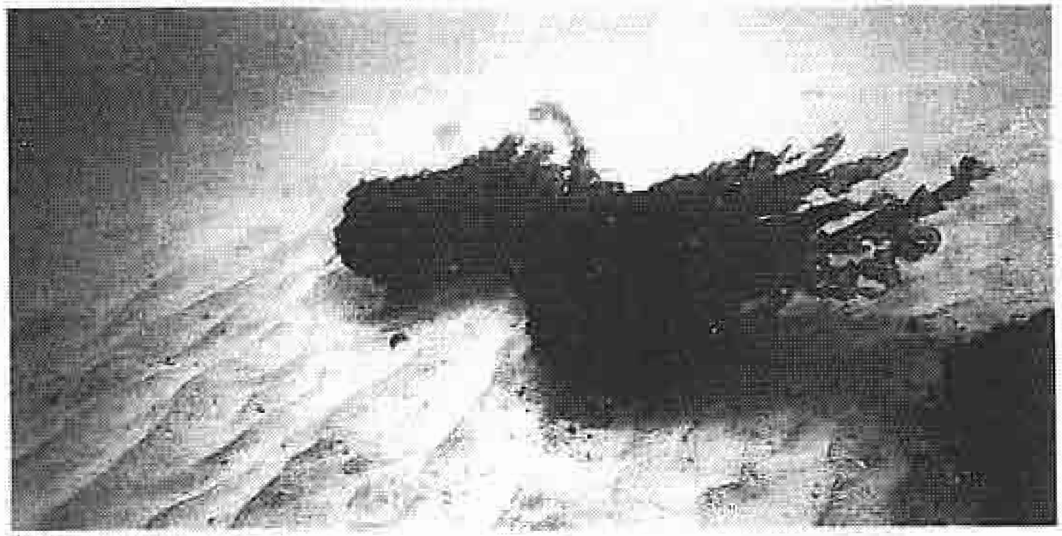
An examination of the site reveals that there is little of the structure remaining beyond the turn of the bilge. When considering whether or not the *Abemama* conforms to the water-line theory we are immediately struck by the fact that this wreck is a burnt hull wreck. This effectively means that the only remains will be from the water-line down and such is difficult to evaluate.

JAMES

This vessel, believed to be a wooden brig,[10] had come to Fremantle overloaded with immigrants and cargo from Liverpool in 1830. Five people had died on the voyage out[11]. She moored in the Owens Anchorage and before unloading was completed she was blown ashore during a heavy squall in the night of 20th May 1830.

The site of the *James* was located with ease. This was however despite the lack of much visible material. The only sign of the wreck at this time was the long keel bolts that protruded upwards from the sand. These were examined and it became clear that the wood that lies beneath them was to far below surface to allow anything other than a cursory examination of the site.





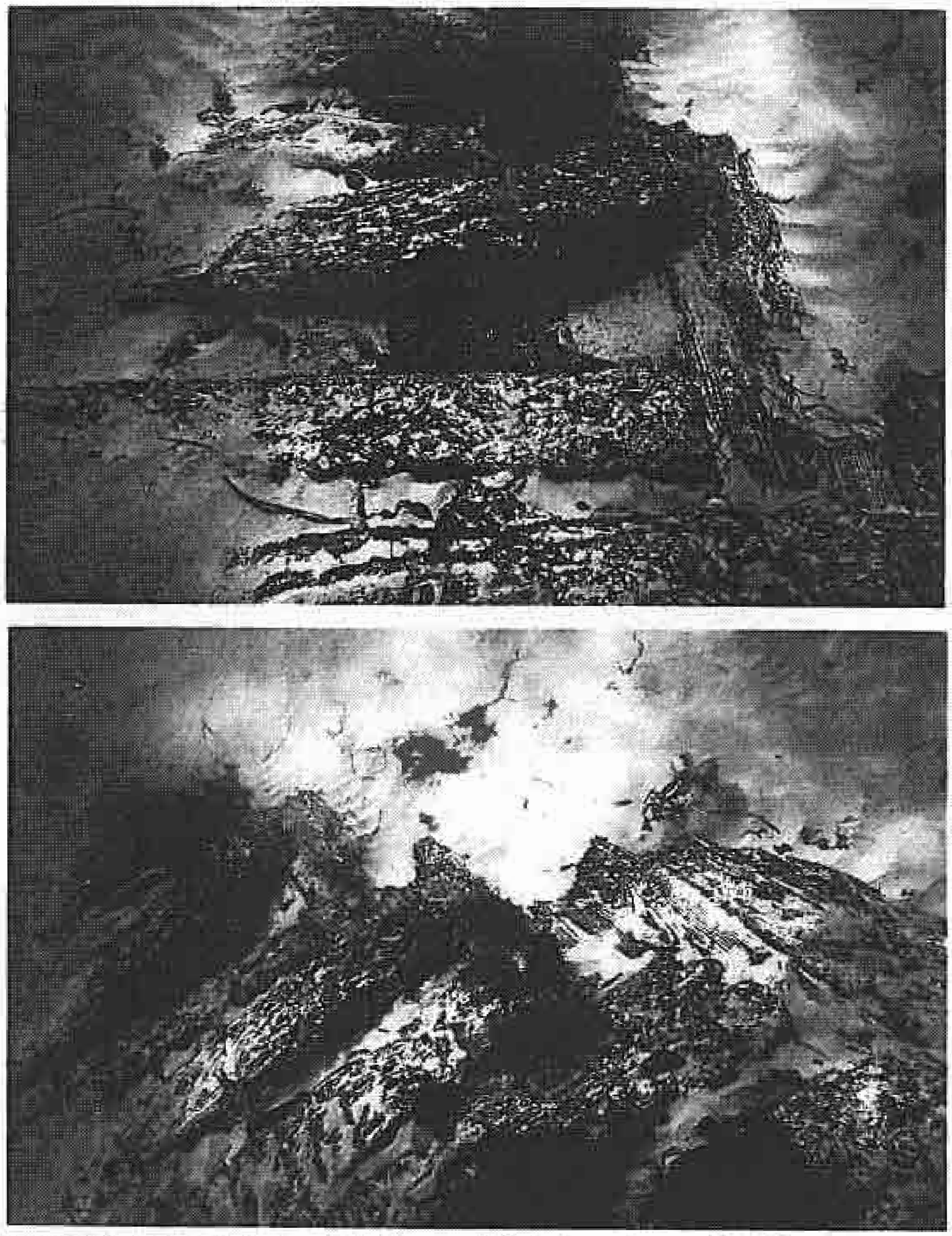
Figures 19 and 20. Weed covered keel bolts mark the location of the *James* wreck site.

Previous visits to the *James* have been far more revealing. The wooden keel, a number of ribs, copper spikes and yellow metal sheathing remain. Guns have been recovered from the site and one the '*James* Carronade' is on display in the Maritime Museum.

DIANA

The *Diana* first came into Fremantle on July 4, 1878 having just struck the Parmelia Bank. She was able to extract herself through the efforts of her crew and arrive in safe waters.[12] However, during the severe gale on the night of July 15, she parted both cables whilst at anchor at the Owens Anchorage, and ran ashore. Whatever happened to her after that remains unclear, however an examination of the site found that the remains were most easily located.

The remains appear more visible than they have been for some years[13]. The keel and ribs are clearly distinguished as is the planking attached. There is little that remains up to the point of the turn of the bilge. The seaward side has fared less well than the landward side. The length of the ribs are clearly shorter on the outer side. A discussion of the reasons for this will follow later in this section.



Figures 21 and 22. Ribs and planking of the *Diana*, with little above the turn of the bilge.

IRON VESSELS LYING ON REEF

HIGHLAND FOREST

This three masted iron barque struck the Murray Reef with the fullest force. All sails were set and the weather was good. The remains of the vessel are scattered over a wide area of reef. Some of the remains lie broken in gullies where they are to an extent protected, including some spars. The majority of the remains lie exposed on the uppermost part of the reef in comparatively shallow water. When recently visited in poor visibility the wreck took on the classic junk yard appearance, with few distinguishable features, though no doubt a substantial survey would reveal more.

The conditions on site can comprise substantial prevailing westerly swells, which when reaching the shallow water build up and are augmented substantially when they hit the reef. Even on calm windless days, the surge can be most forceful. Having originated in some long finished distant storm, the water movement flows up and over the prominent rock formation and can produce a prefect breaking wave over the reef. This is despite the reef being quite far off-shore. For a diver surveying the site, these water movements are most apparent. They push the diver steadily back and forth just as easily as the fronds of sea weed .

There is an important issue here. All prominent features will be heavily affected by the surge. Initially, when the hull plates are all in place, the wreck will suffer great to and fro force in even the mildest swell, This will 'work' the wreck. Any weakened feature will suffer progressive action until torn away. As each plate opens up, more power will be exerted to the features that remain, until the wreck is reduced to a junk pile that has a comparatively low profile and combines with the existing reef topography.

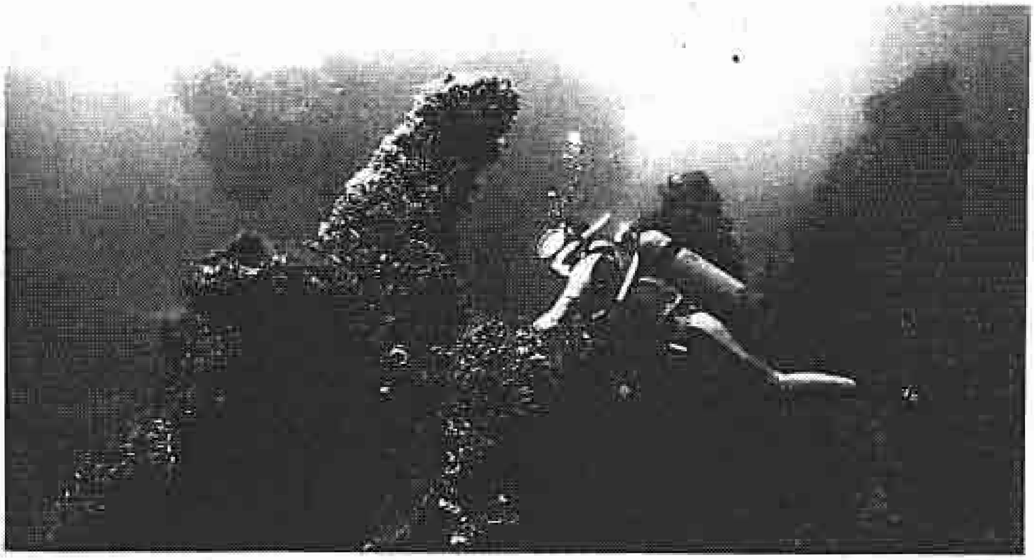


Figure 23. Rib section of *Highland Forest's* remains.

Figure 24. A more predominant feature on the wreck of the *Highland Forest*.

JAMES SERVICE

The wreck lies in between 5 and 8 metres of water. The orientation of the keel is close to east west with the bow to the west. The remains spread out over an area of approximately 12 by 60 metres. Overall the structure rises up to a maximum of 2.5 metres above the seabed. The bow section lies collapsed towards the stern. Ribs comprise the main protruding remains. Few of the forward plates are still in place, except a section 1 metre high on the starboard side, running from the bow 30 metres aft. Keelson and ribs are visible in the central part of the wreck. Loose plating is scattered around the site and sections of mast are also visible. Steering gear remains are found to the rear of the wreckage forming the usual anchor like appearance. Deadeyes can be seen forwards in the wreck[14].

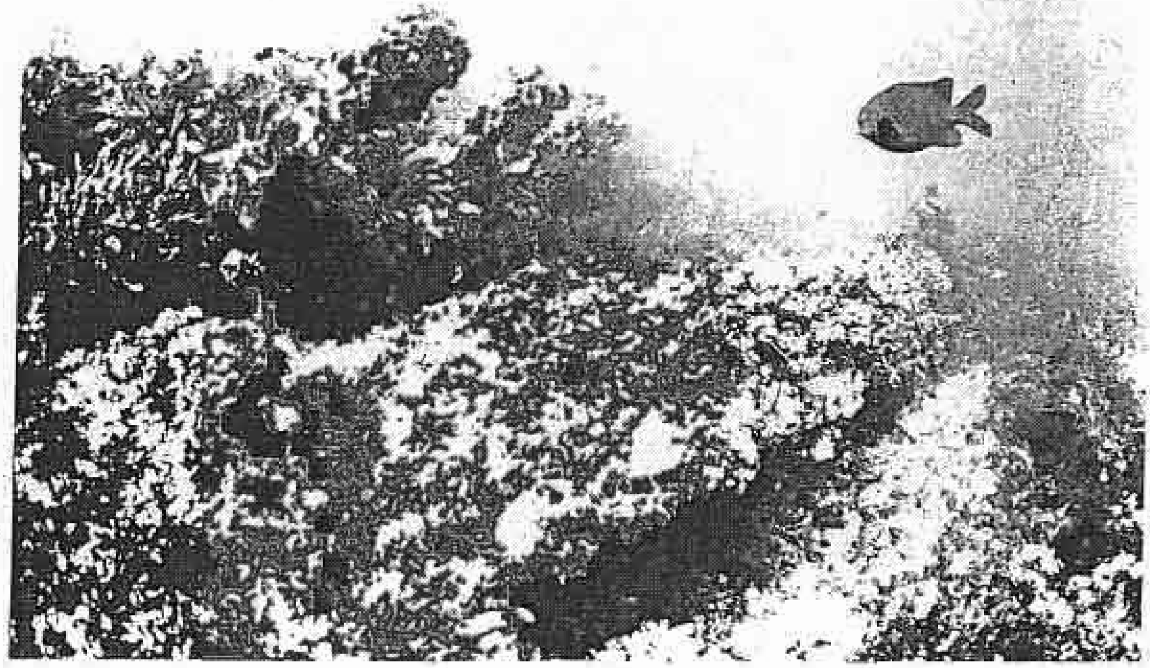


Figure 25. Deadeyes protruding from the general wreckage[15].

Figure 26. Ribs and plating extend upwards[16].

Figure 27. Steering gear easily mistaken, as on other sites, for anchors[17].

WOODEN VESSELS LYING ON REEF

CHALMERS

The wreck lies in 4 to 7 metres of water. The bottom topography comprises a combination of sandy patches and coral outcrops. The remains lie on a near north south axis with the stern to the north.

Where it can be seen amongst the marine growth, the hull is largely broken up with only a few timbers visible above the sand. Two sections or keel are exposed each at different ends of the site. The most obvious feature of the site is the substantial quantity of unquarried small ballast stones, that would account for several hundred tons of ballast. A number of yellow metal fastening bolts can be seen scattered amongst the remains, many of them no longer attached in any way to ships timbers[18].

As can be clearly seen in the sketch plan below the remains of the *Chalmers* are lying on a sand bottom. In this case therefore, whilst this ship was wrecked on a reef, it fell into a sand filled gully. This identifies a case that must be treated differently from the four basic categories that were identified initially. It is probably more appropriate to consider this wreck as a wooden wreck lying on sand, but no doubt effected in its degradation by the dynamic effects of surge over a reef and whatever effect the rocky overcrops surrounding the wreck have.

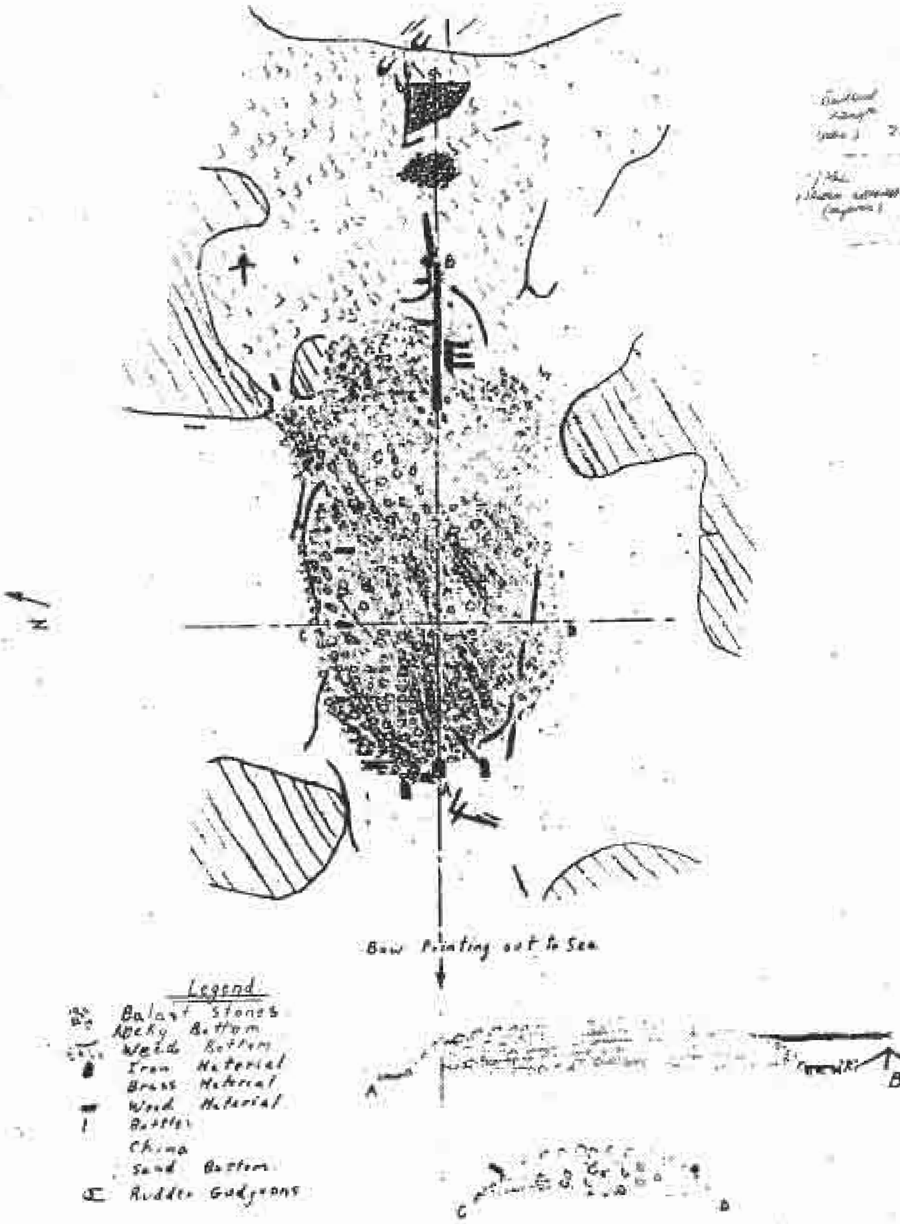


Figure 28. Sketch plan of *Chalmers* wreck site[19].

STAR

The remains of this wooden whaler were examined during a survey in 1983, and a photomosaic was produced in 1986. Being a locally constructed ship the information that has been obtained about this vessel is most interesting. When uncovered, the remains did not prove insubstantial. The photomosaic shows parts of keel and keelson along with ribs and planking.

It appears that this wreck again is in a similar position to the *Chalmers*, described above, where it lies on sand. As with the *Chalmers* the rocky ballast mounds are responsible for much of the protection of the remaining timbers.

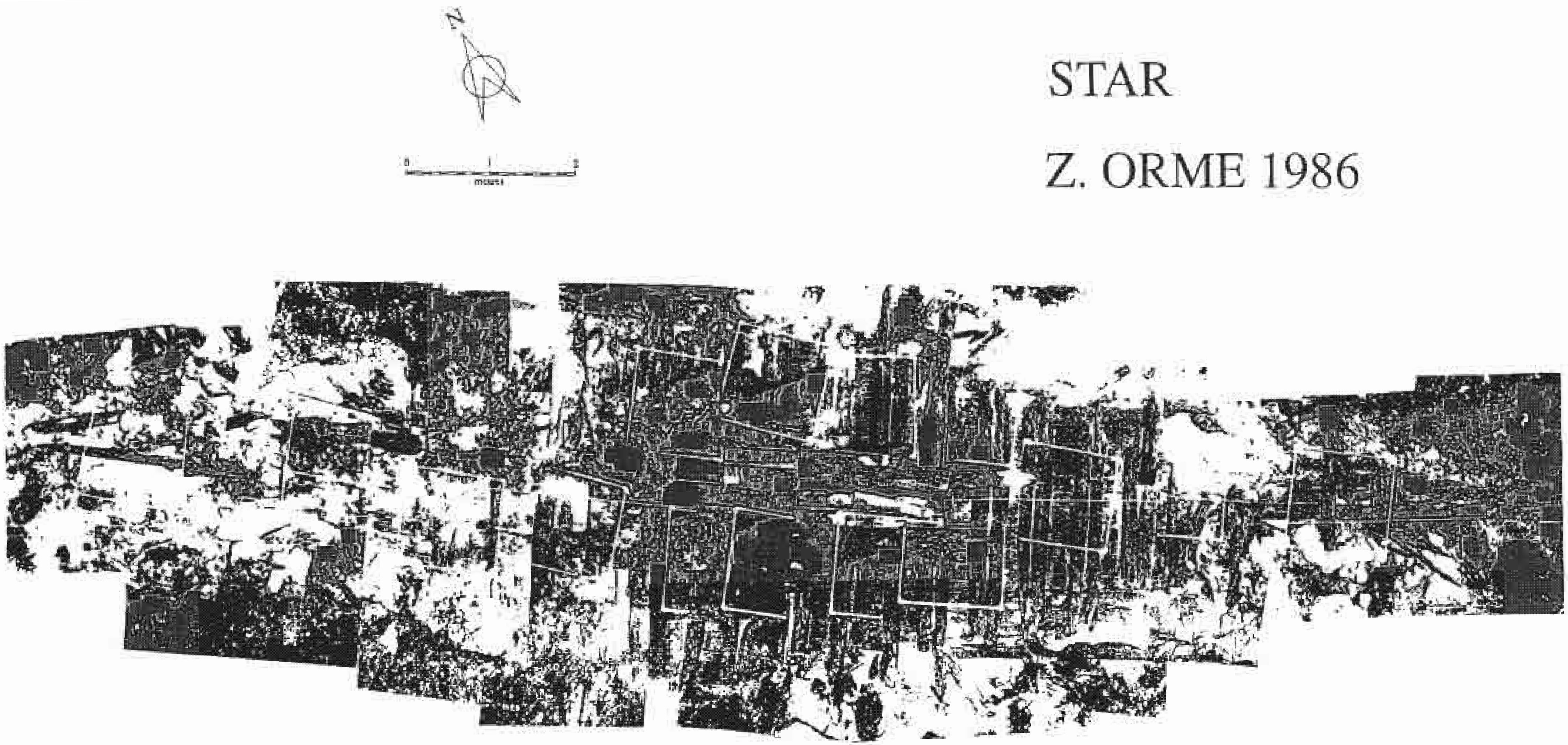


Figure 29. Photomosaic of the Star wreck site[19]

ROBERTINA

The *Robertina* was a 231 ton two masted wooden brig. She struck the Murray Reef, November 2 1859. The remains of the *Robertina* lie approximately 7 metres of water in a reef gully. The spread of visible wreckage is approximately 25 x 8 metres. The wreck is orientated in line with the gully and a mound of material follows along the centre line of the wreck. This comprises keelson bolts, sections of pump, iron knees, timber fragments and pieces of sheathing.

SHIPWRECK DISINTEGRATION AND DEGRADATION: SOME CONCLUSIONS.

Having earlier considered the water-line theory of wreck degradation, as put forward by John Riley for iron wrecks on sand, and having studied the remains of a number of shipwrecks and their sites, it is now interesting to examine how the water-line theory relates to the findings described above.

The first group considered in the surveys above was of course iron vessel on sand. These were the *Alacrity* and the *Omeo* . These vessels were beached, and as has been seen in the preceding photographs, subject to a slow degradation. Without the steady surging movements that play so heavily on rigid iron plates, the weathering effect on the wreck has been quite slow. Both wrecks to some extent have settled into the sand but are largely outside the types described by Riley. A future study of other wreck categories may well be fruitful then, that encompasses wrecks that are beached. In the meantime given the wide nature of Riley's study more is to be gained from the comparison of different types with his theories.

Considering the situation of wooden wrecks on sand, those locally visited were the *James* and *Diana* . They appear to produce a predictable disintegration pattern. Once in a settled position, whether on the seabed or on the beach, the remaining structure will collapse as its supports degrade. However, just as iron shipwrecks on sand may, as John Riley points out, sink into the new interface to the water-line, so can wooden ships. The extent to which this will take place depends on the local conditions. The *Diana*, in Jervoise Bay, may not have sunk into the sand as much as other wrecks in perhaps deeper waters or softer sand, but the remains are those protected by sand and marine growth after the majority of the hull has been lost. We should note the important effect of weed fronds slowing water down and allowing the deposition of suspended sand. This process has been used to great benefit as an anti-scour device on off-shore hydrocarbon pipelines and more recently for the same purpose on the wreck of the *William Salthouse*[21].

The diagrams overleaf, including those made for the *Gemma* site also in Jervoise Bay, shows most clearly how wooden wrecks can collapse, leaving a variety of remains.

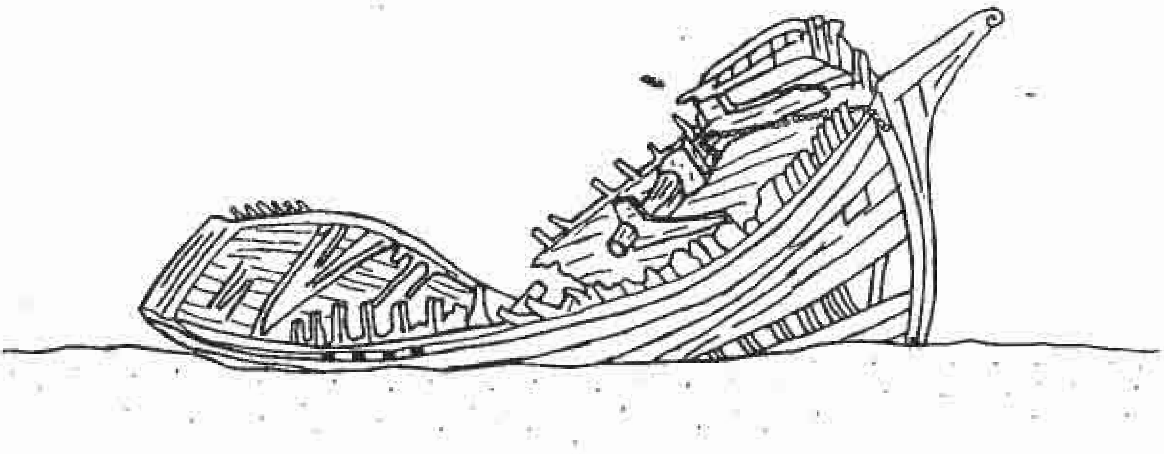


Figure 30. A wooden ship having beached quickly looses its structural strength[22].

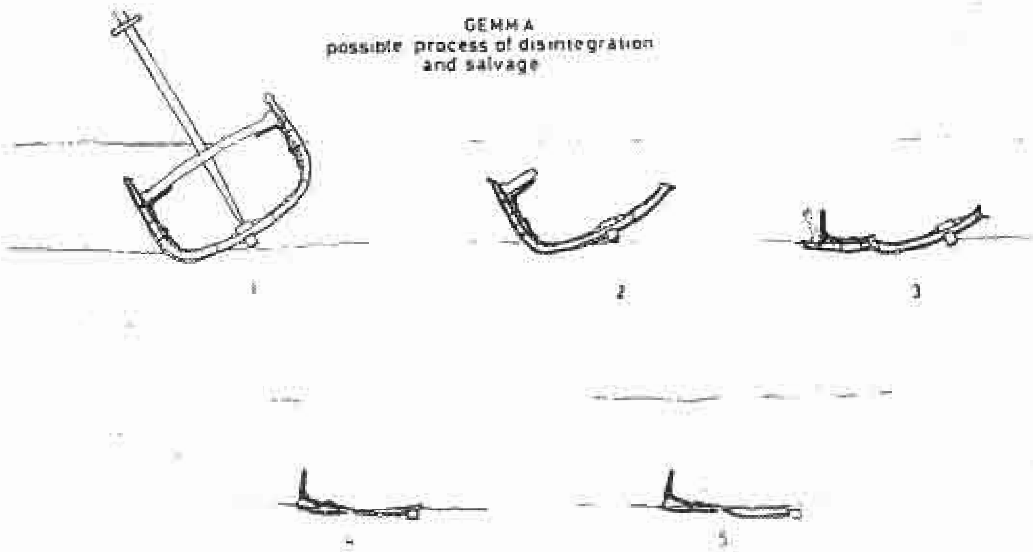


Figure 31. A series of sketches representing the process of disintegration.[23].

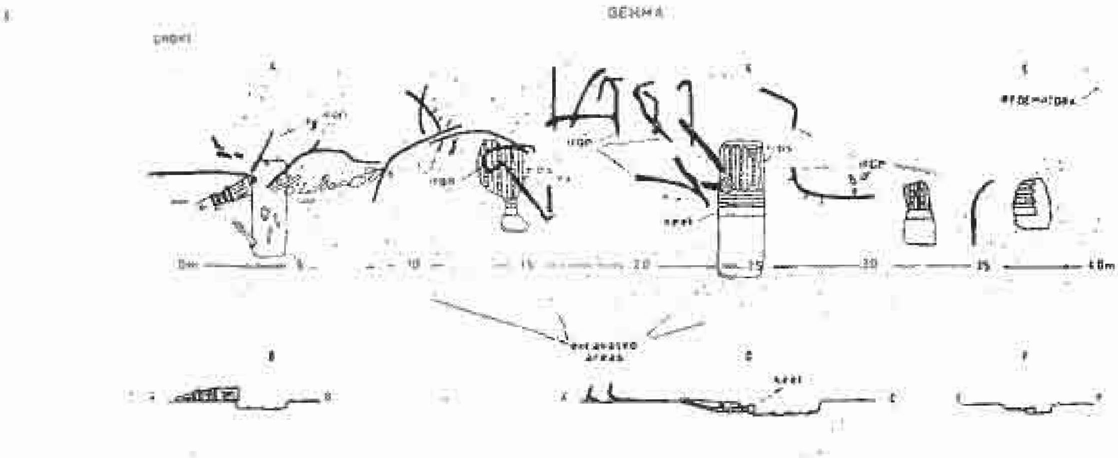
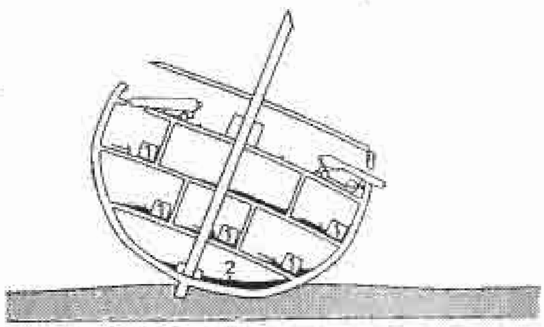


Figure 32. The *Gemma* site plan showing sand protecting the denuded remains[24].

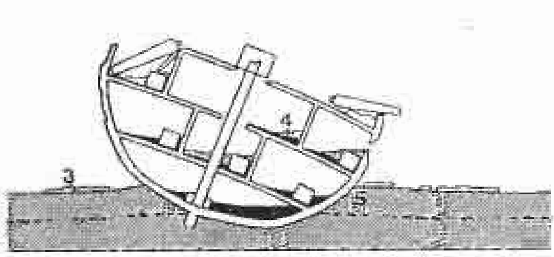
Under different site conditions wrecks will clearly degrade differently. Whilst it could be called a 'beached' shipwreck, the *Amsterdam*, when it struck Bulverhythe beach, Hastings, Sussex in 1748, was quickly absorbed into remarkably soft sands[25]. Similarly, the *Mary Rose* wrecked in deeper waters initially sank into and was later covered by the local soft silt. The *Pandora* also appears to have been preserved to some degree by this action. This varied process of degradation of a recognisable wooden ship into a covered remnant has been outlined before[26] and developed by further studies[27].

Possible stages of disintegration. *(Sally Elmer)*



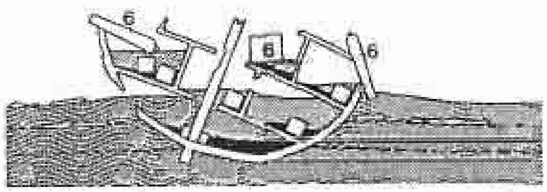
Stage 1 (Approx. one year after sinking)

Masts and rigging have broken off and floated away; weakened quarter and focsle deck bulwarks have broken off and been dispersed by currents. Small artefacts accumulate in clusters against internal partitions and bulkheads (1). Gradual silting-up begins as organic materials decay and fine particles are trapped within enclosed hull spaces (2).



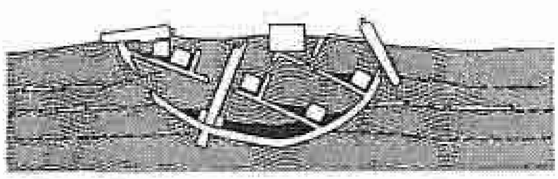
Stage 2 (Approx. one to ten years after sinking)

Parts of the upper deck deteriorate and collapse due to marine borer activity. Some of the upper deck structural timbers fall away onto the seabed (3). Currents deposit coarser sediments into semi-enclosed hull spaces (4) and carry away and disperse light artefacts. Gradual seabed build-up occurs under and around the hull (5). Fine particle build-up continues within enclosed spaces.



Stage 3 (Approx. ten to fifty years after sinking)

Continuation of processes started in Stage 2; more collapse of structural timbers; continued fine particle build-up in enclosed spaces and coarse sediment accumulation in semi-enclosed spaces. Seabed build-up continues around the hull. Heavy iron objects — eg cannon and ship's stove — drop down into lower areas of the hull (6).



Stage 4 (Approx. fifty to eighty years after sinking)

Wreckage approaches stabilisation. All spaces within the hull filled with compacted fine or coarse sediments. Seabed build-up has been completed. Marine borer activity ceases due to effective cover by sediments which insulate organic materials from oxygen.

Figure 33. The suggested degradation of the *Pandora*, a wreck in deeper water shows the combination of slower initial degradation and a build up of silt deposits around the new seabed feature[28].

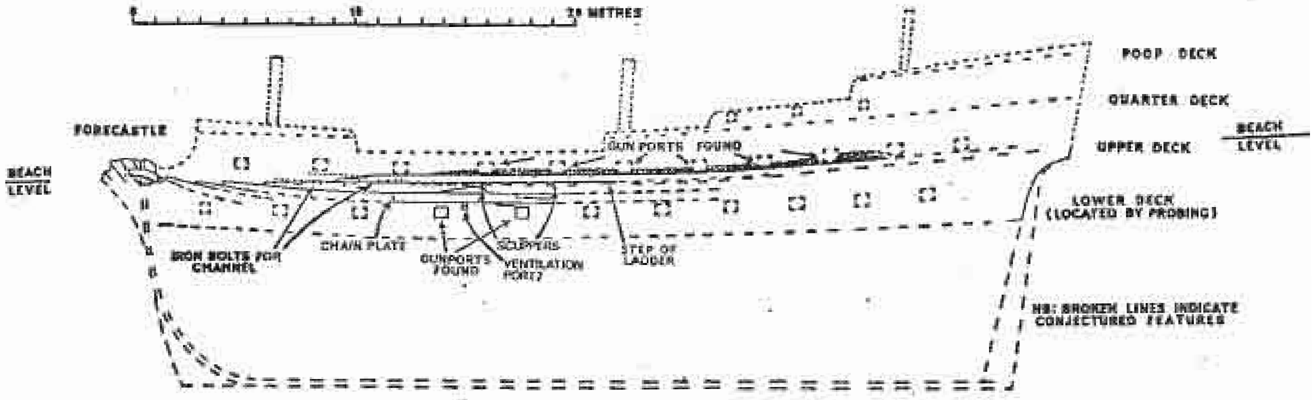


Figure 34. The *Amsterdam* was a beached wreck, but the extremely soft sand swallow her up causing a greater proportion of her to be preserved than the local wrecks examined[29].

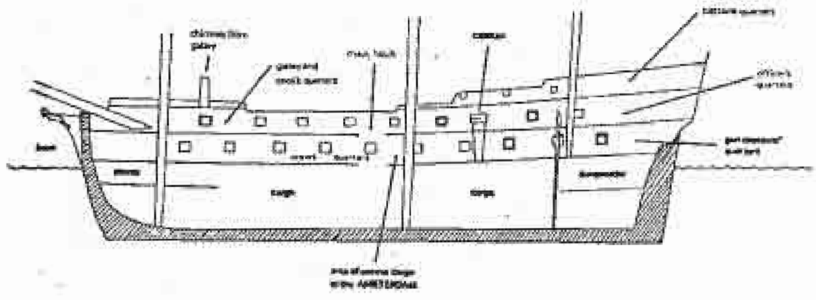


Figure 35. A comparison between this illustration and figure 34, shows the water-line of the *Amsterdam* is actually well below the eventual level that the wreck sank to[30].

It appears therefore, that a shipwreck lying on a sandy seabed receives varying degrees of support from the sand into which it sinks, with local conditions dictating the results.

If we now consider wrecks that have taken place in a reef environment, one would immediately expect a different result. These wreck sites may well have had more violent and destructive beginnings. A reef by its nature is not a fluid to fluid interface, as sand to water may to some extent be. A reef is largely incapable of giving in and cradling the vessel that has landed upon it. The reef may be smashed to some extent by the initial force of impact ,but then there would be little left to support in any case.

Examination of the *Highland Forest* and *James Service* sites does leave a sense of the destructive power that surrounds the wrecks. Riley describes an iron wreck on a reef as with, 'The hulls collapsing around the rocks like wet cardboard around bricks.....soon loosing their layout'[31]. There is nowhere that the reef can give way to the hulls shape. It may grind something of a niche for itself in the reef but in the process it will be greatly damaged.

Thus an iron wreck on reef can have a real junk yard appearance to it. The survey and photomosaic of the *Ben Ledi* site on the Abrolhos, clearly illustrates this. However, when such a survey is examined it can be seen that there are clearly recognisable remains. The bottom of the ship is distinguishable and has remained in place probably due to its low profile and weight.

All is therefore not lost in this environment. The plates can trap artifacts and in some instances the remains can show clear disintegration patterns. The *Ben Ledi* wreck, having lost its deck beams, has seen many of its plates fall outwards,[32] opening up the wreck. Also stronger items remain recognisable such as the bow.

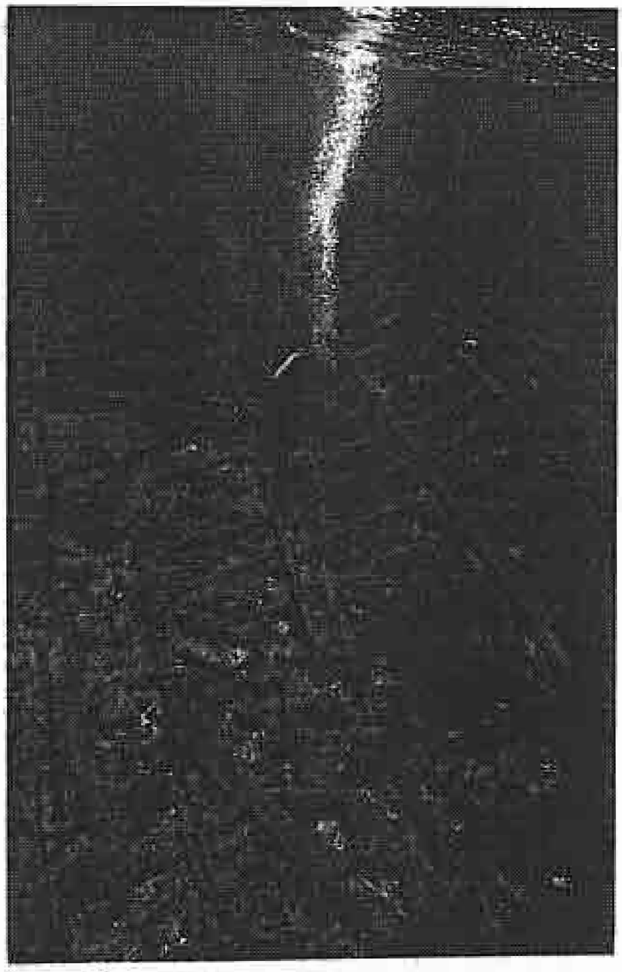
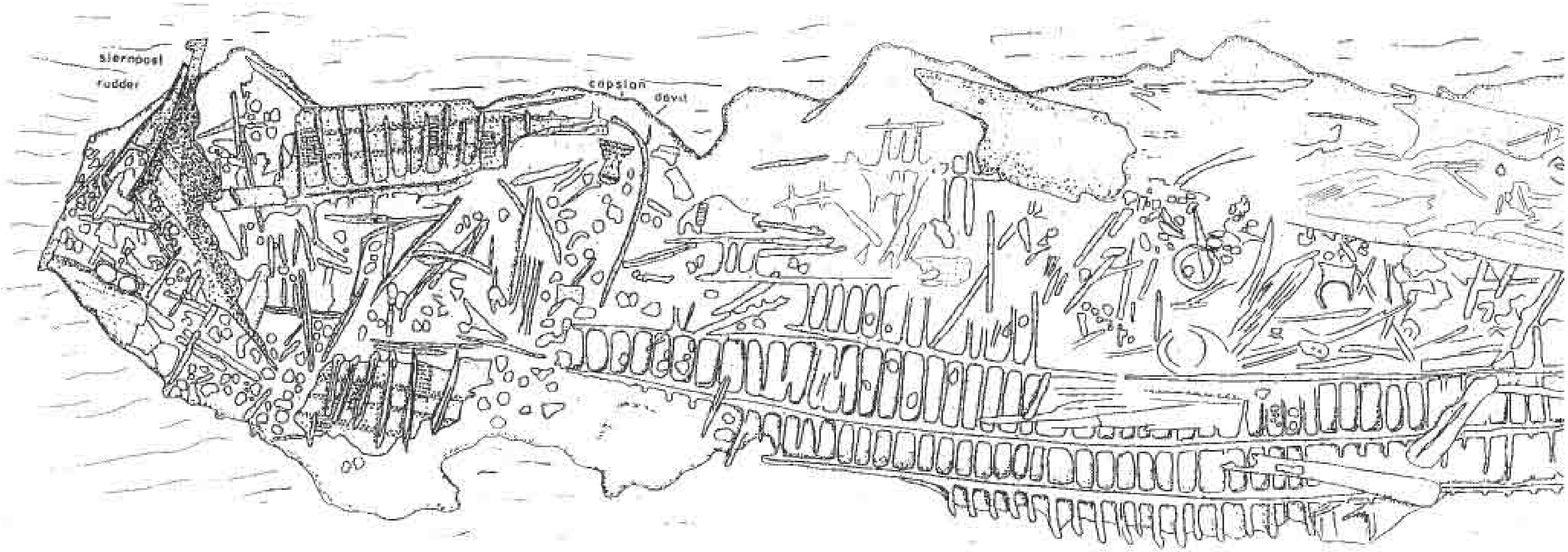


Figure 37. A diver at work surveying the remains of the *Ben Ledi*. The ribs and plates of the construction are clearly seen[33].



BEN LEDI

SITE PLAN

Figure 36, The *Ben Ledi* site plan[31]

Figure 38. The stern of the *Ben Ledi* is more distinct amongst the broken wreckage.

The destructive power of the reef environment will also take its toll on the wooden wreck. The *Chalmers*, *Star* and *Robertina* have benefited from the existence of sandy areas and gullies that have helped preserve some of their remains. Typically, ballast stones have also played their part where they have stopped the ravages of both surge and marine borers. Locally hard marine growth may combine with the stones and form a protective layer that preserves the timbers very well indeed. The Batavia timbers are of course, fine examples of how valuable wooden hull structures can survive against the odds, in a harsh reef environment.

Figure 39. Timbers from the V.O.C. ship *Batavia* lying on an Abrolhos reef. The stern quarter is clearly seen

SECTION TWO

WRECK TRAIL PROMOTION

The Mandurah Wreck Trail and Anchor Park, and the Hamelin Bay Wreck Trail were conceived some time ago within the Maritime Archaeological department of the W. A. Maritime Museum. They are part of a wider policy of promoting responsible wreck diving in the region.

As they were due for development about the time that this study was to commence, it was decided to incorporate the work jointly. This had the benefit of providing hands-on experience of a real museum project, with academic study.

Due to the unfortunate distractions abroad the work has been interrupted but will be completed this December.

Every effort has been made to unify the archaeological issues that are the main thrust of this work with the practical requirements of a full museum project. The following report contains a description of the project aims and copies of plaques that are being installed in various locations.

THE MANDURAH AND HAMELIN BAY WRECK TRAILS DESIGN, INSTALLATION AND PROMOTION

MANDURAH

The five underwater wreck plinths for the Mandurah Wreck Trail are scheduled and organised for installation on the 15th of November 1991. This has and will involve:

1. Collection of the redundant block type wreck plinths from Mr. Jim Archibald's storage yard. Cranage and recovery by truck to Finnerty street Fremantle. Organise personnel and equipment to conduct beach magnetometer search for the *Georgette* propeller. This was executed the same day and all personnel returned to Fremantle.

3. Compiling text and artwork for the Mandurah plaques. Sourcing correct specification glass form Pilkington and delivery to Almark for printing.

4. Painting and renovating the original blocks at Finnerty street, removal of the former glass plaques and installing the new ones.

5. Logistical organisation of transport, cranage, personnel and museum vessel *Henrietta*, to load *Henrietta* ready to sail south.

6. Liaison with Graham Anderton to facilitate pre-buoying of the five wrecks with involvement of pupils from South Fremantle Senior High School.

7. Installing first three blocks from *Henrietta*, photographing their location on the seabed.

8. Organising overnight accommodation at Mandurah for operations team.

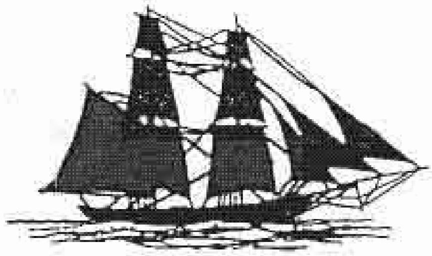
9. Transportation of the remaining two blocks by truck to Mandurah, organising cranage and berth for *Henrietta*, to collect second batch of blocks.

10. Installation of the remaining three blocks on seabed and photographing their location.

THE MANDURAH WRECK TRAIL UNDERWATER INFORMATION PLAQUES.

HISTORIC SHIPWRECK

ROBERTINA



BRIG

This 213 ton two masted wooden brig was built at Greenock in Scotland in 1843. She was 26.3 metres long with carvel planks, a square stern, standing bowsprit and a female bust figurehead.

On 2 November 1859 she left Fremantle carrying timber, flour and whale oil for the Adelaide Market. In a smooth sea and in fine weather she struck the Murray Reef and quickly sank by the head, leaving just 1 metre of her stern above the water. The twelve crew and seven passengers hardly had time to board the boats.

The wreck was discovered in 1987 by local diver Graham Anderton, and identified by the bell which bore the inscription 'Robertina 1843'.

This wreck is free for your examination and enjoyment but has been declared historic under the provisions of the 1976 Historic Shipwrecks Act. As such no physical interference must take place under penalty of law. Further information can be obtained on this and other wrecks at the W.A. Maritime Museum, Cliff Street, Fremantle.

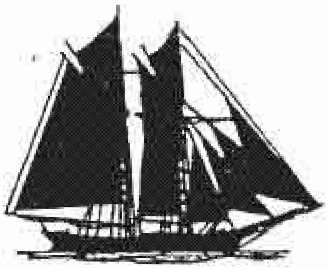
City of Mandurah

South West Development Authority

Western Australian Maritime museum

HISTORIC SHIPWRECK

STAR



SCHOONER

ADJACENT ARE THE REMAINS OF A WHALER, BUILT IN FREMANTLE IN 1876 BY THOMAS MEWS, FOR A MR. J.W. BATEMAN. SHE WAS A TYPICAL COLONIAL CRAFT, 70 TON, FORE AND AFT RIGGED SCHOONER, WELL BUILT AND NEATLY CONSTRUCTED OF LOCAL WOODS. IN OCTOBER 1880, WHILST RETURNING EMPTY-HANDED FROM A VOYAGE TO GEOGRAPHE BAY, SHE STRUCK THE REEF AND SANK.

ALL THOSE ON BOARD SURVIVED BUT THE VESSEL WAS A TOTAL LOSS. A FEW ITEMS OF EQUIPMENT WERE SALVAGED BUT LITTLE OF THE HEAVY EQUIPMENT INVOLVED IN WHALING.

THE REMAINS OF THE WOODEN HULL MAY BEEN SEEN AMONGST BALLAST ROCKS AND METAL ITEMS. THE WRECK WAS SURVEYED IN 1983 BY ARCHAEOLOGISTS FROM THE W.A. MARITIME MUSEUM.

THIS WRECK IS FREE FOR YOUR EXAMINATION AND ENJOYMENT BUT HAS BEEN DECLARED HISTORIC UNDER THE PROVISIONS OF THE 1976 HISTORIC SHIPWRECKS ACT. AS SUCH NO PHYSICAL INTERFERENCE MUST TAKE PLACE UNDER PENALTY OF LAW. FURTHER INFORMATION CAN BE OBTAINED ON THIS AND OTHER WRECKS AT THE W.A. MARITIME MUSEUM, CLIFF STREET, FREMANTLE.

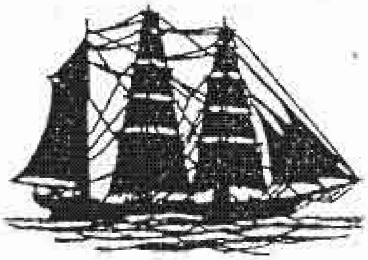
CITY OF MANDURAH

SOUTH WEST DEVELOPMENT AUTHORITY

Western Australian Maritime museum

HISTORIC SHIPWRECK

JAMES SERVICE



BARQUE

Iron hulled three masted barque of 455 gross tons. Built by Dobie & Co., Scotland in 1869 and owned by James Service & Co., Melbourne.

En route To Melbourne from Calcutta she was carrying a cargo of gunnies, castor oil and jute. Amongst several passengers were seven members of a theatrical touring company.

Her loss on the 23 July, 1878 was a great disaster. All passengers and crew perished. Bodies were washed up along the coast for months as was a diary kept by a passenger. It told a fearful story of heavy weather for many days, the loss of the ship's mizzen mast and an attempt to beat north for Fremantle for repairs. During the fateful night the ship struck and sank on the northern end of the Murray Reef and though seen in distress from the shore it was impossible to launch boats in the violence of the storm.

Her remains now lie around you. The hull is resting on its port side. The bow projects towards the reef where she stuck. The stern is on sand to the east. Winchgear can be found amongst the wreckage and in some places deadeyes are still attached to the hull by chainplates. Much of the hull plating has come away leaving just ribs exposed.

THIS WRECK IS FREE FOR YOUR EXAMINATION AND ENJOYMENT BUT HAS BEEN DECLARED HISTORIC UNDER THE PROVISIONS OF THE 1976 HISTORIC SHIPWRECKS ACT. AS SUCH NO PHYSICAL INTERFERENCE MUST TAKE PLACE UNDER PENALTY OF LAW. FURTHER INFORMATION CAN BE OBTAINED ON THIS AND OTHER WRECKS AT THE W.A. MARITIME MUSEUM, CLIFF STREET, FREMANTLE.

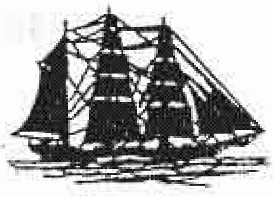
City of Mandurah

South West Development Authority

Western Australian Maritime museum

HISTORIC SHIPWRECK

HIGHLAND FOREST



BARQUE

This iron hulled three masted barque of 998 tons left New York for Fremantle 22 January 1901. Consigned to the W.A. Shipping Association, she carried a general cargo of steel plates, kerosene, white pine shelving, chairs, barrels of asphalt, cornflour, paper and windmill apparatus.

In splendid weather this heavily laden vessel, with all canvas aloft, struck the Murray Reef with the fullest force. The eighteen hands on board at the time were saved but nearly all property was lost. In the Customs House in Fremantle, charges against Captain Alexander Chapman led to suspension of his certificate for twelve months.

Built in Lieth, Scotland 1884, this once fine vessel is associated with the author Joseph Conrad. He was chief mate on a voyage from Amsterdam to Java in 1887 and was one of seven vessels on which he sailed that were subsequently lost.

Well known local diver Rudi Kreuzer, found the vessel in 1968 and has donated the ships bell to the W.A. Maritime Museum where it can be viewed today.

This wreck is free for your examination and enjoyment but has been declared historic under the provisions of the 1976 Historic Shipwrecks Act. As such no physical interference must take place under penalty of law. Further information can be obtained on this and other wrecks at the W.A. Maritime Museum, Cliff Street, Fremantle.

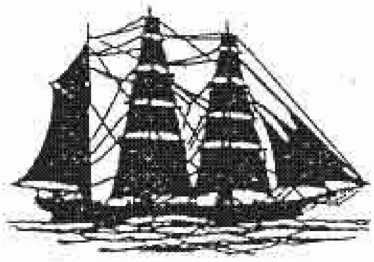
City of Mandurah

South West Development Authority

Western Australian Maritime museum

HISTORIC SHIPWRECK

CHALMERS



BARQUE

One of the larger wooden vessels of the colonial trade this 606 ton barque was built in Sunderland in 1851.

On the night of 19 March 1874, with a cargo of Mauritius sugar for Fremantle she ran into trouble when mistaking bushfires for the Rottnest light. Sighting the reef she kedged off and held in a good anchorage for about an hour. However the master then "recklessly tried to take a passage through the rocks without first ascertaining that such a passage did exist"

This act led to Captain W. Alexander being charged with incompetence and negligence. Found guilty, his masters ticket was cancelled.

The wreck was dismantled as much as possible. Sails, rigging and gear were removed for auction.

The remains lie approximately on a north south axis with the stern to the north. The stones are the ships ballast but some timbers and fastenings may be found.

This wreck is free for your examination and enjoyment but has been declared historic under the provisions of the 1976 Historic Shipwrecks Act. As such no physical interference must take place under penalty of law. Further information can be obtained on this and other wrecks at the W.A. Maritime Museum, Cliff Street, Fremantle.

City of Mandurah

South West Development Authority

Western Australian Maritime museum

The eight various foreshore information plaques for the Mandurah Wreck Trail and The Mandurah Anchor Park, are organised and scheduled for installation in late November 1991. This has and will involve:

1. Weekend reconnaissance of proposed foreshore sites at Golden Bay, Singleton, Madora, San Remo, Silversands and Hall's Head Mandurah. Conducted 19th and 20th January 1991. Checking condition of the Anchor from the *James Service*, photographing and reporting to conservation dept.

2. One week spent locating potential anchors for donation to the anchor display.

3. Writing text and compiling artwork for the foreshore wreck trail plaques and the anchor display.

4. Sourcing suppliers of aluminium plaques and organising their construction.

5. Liaising with Les Cousins of The South West Development Authority to ensure construction of frames and mounts for the plaques at Hall's Head, Mandurah and the satellite north of Mandurah.

6. Installation of the plaques within the frames and plinths. Taking photographs of the plinths and anchor display for promotional purpose.

7. Liaising with local media to create publicity for the Wreck Trail.

8. Acquiring the G.P.S. co-ordinates and new transit photographs of each site.

THE MANDURAH WRECK TRAIL FORESHORE INFORMATION PLAQUES.

The Mandurah Wreck Trail

Before you now there lies a hidden history. As you look across this bay, beneath the seas are the remains of many fine ships. Their ribs ar role in the history of this region. If you are a diver you may enjoy them with a visit in person, but dwell for a moment on the lives of these shi

Alert 1875

This un-insured, Fremantle built cutter went aground on the Murray River bar when bound from Pinjarra to Perth. John Kelly was blamed for making what was known to be a dangerous crossing in winter, despite having been under the instruction of the vessel's owners. However, being an uncertificated master he could not be brought in front of an official inquiry.

Bee 1851

The Bee was a small schooner that must have been fated, for in the two years before its loss it ran aground twice, requiring its recovery and repair on each occasion. Later in May 1851, it was caught in boisterous weather and became a total loss. Fortunately, no lives were lost but some of the cargo was destroyed. Flour carried on board was saved as sea water only penetrated the sacks some 5 centimetres.

Belle of Bunbury 1886

A modest 42 ton schooner that came to its end just off Penquin Island. It carried potatoes and wool and these were lost with the vessel when it foundered in 3 fathoms of water.

Black Swan 1851

The 14 ton cutter *Black Swan*, was employed by the local shipowner Anthony Curtis to run between Fremantle and Castle Rock, south of Busselton, with cattle for the Fremantle market. The advertised rates were 30/- for Bunbury and 40/- for Vasse. On one particular night night in May 1851 it was reported wrecked. Running aground on the Murray River bar and unable to shift before a gale arose, it was doomed and became a total loss.

Bungaree 1876

This schooner left Batavia (Jakarta) for Fremantle with a 32 ton cargo of sugar and sundries. Late in its voyage its position was uncertain as bad weather had obscured navigational sights for a number of days. At 4.30 a.m. the mate gave 3 minutes warning of breakers, but it struck with its starboard bow. Waiting until sun up the crew were able to get away in a boat but only after two attempts were swamped.

Carlisle Castle 1899

This iron barque of 1484 tons was lost on Coventry Reef with all hands. Captain Lindsay could probably not get a fix by sun or star, or take soundings due to the weather. In the heavy seas of the storm it was pounded into the reef and with its heavy cargo of rails, the ship sank quickly to the spot where today it is a very popular dive site. The entire crew was lost.

Chalmers 1874

Carrying sugar from Mauritius to Fremantle, the Chalmers struck the Murray Reef on the 19th March 1874. The Captain, William Alexander, had mistaken a mainland bush-fire for the Rottnest light. This act was considered so negligent that the Captain lost his ticket altogether. Bought by Messrs J.&W. Batemen for £19, the wreck was dismantled as much as possible though the cargo was destroyed.

The remains were discovered in 1975 by local skindivers and lie in 4 to 7 metres of water on the inshore side of the small breaking reef just south of the Sisters reef. This was a well built, ship rigged vessel and today parts of its wooden hull can be seen covered by ballast stones.

Coorong 1889

Stranded on the Murray Reef, this 369 ton barque had just made the voyage fro Adelaide. Captain Hayward was unable to see the land due to haze. It was lucky to b able to re-float and undergo repair.

Hero of The Nile 1876

Sailing with sand ballast to collect guano from the Lacepedes, the Captain had onl a general chart of this area, and was not taking soundings. At 2 p.m. on October 20th hit Long Point. Backing the sails had no effect, so they were furled. The vessel bumpe heavily all night, taking considerable water as the pumps choked with sand ballast. It wa abandoned, later condemned by survey and sold. The Court of Inquiry placed no blam on the Captain and cited the inadequacy of the charts as unsatisfactory for clos navigation. The remains of the 356 ton barque lie in 3 metres of water on sand and wee 300, metres north-west of Long Point.

Highland Forest 1901

En route from New York to Fremantle, this iron hulled three masted barque mu have made a splendid sight, sailing in splendid weather with all canvas aloft. Striking th Murray reef with the fullest force must have been a massive shock to the eighteen hand on board. Fortunately, all were saved, though all property was lost. Captain Chapma lost his certificate for twelve months as a result.

An interesting aspect of this vessel is its association with the author Joseph Conra who was once Chief Mate. Strangely, six other vessels sailed by Conrad were lat wrecked. Local diver Rudi Kreuzer discovered the wreck and kindly donated the bell t the W.A. Maritime Museum in Fremantle, thereby allowing it to be enjoyed by everyone.

James Service 1878

The story of the loss of this 441 ton, three masted barque, is a truly sad one. It le Calcutta for Melbourne on a return journey with a jute and castor oil cargo, and sever passengers, including seven members of a theatrical company. It was wrecked west of th mouth of the Murray River on July 23rd and all that was seen were masts showing abov the water. The shore was strewn with wreckage and bodies. These were later buried abov the high water mark, at many points along the coastline.

Clues to the circumstances of the loss were only known when a diary was foun washed up on the beach. It told of a long period of bad weather with the barque on it beam ends, the yards touching the water. It was suggested that the vessel had encountere bad weather and was storm damaged. Whatever the cause was, all hands were lost an some now lay buried in the churchyard of Mandurah's Catholic Church, where the ship' anchor is a memorial to the disaster. On occasion, remains of some victims have bee uncovered amongst the dunes, as winter gales shift the beach sands. Recently a sku was discovered.

The wreck now lies in 5 metres of water on the Murray Reef.

Lass of Geraldton 1867

This two masted schooner was built at Champion Bay and had been criticised for i excessively overhanging stern. Some who sailed on it said that unless heavily weighte forward it would bury its bow in the slightest sea. Undertaking its usual coastal trad between Fremantle and Bunbury it was carrying flour and ballast with five crew and tw passengers, including mine owner George Shenton.

On becoming unmanageable in a squall, it heeled over and gradually sank. Fo crew and both passengers were drowned. The schooner went down in 14 metres of wate some 4 kilometres off-shore.

Enjoy the Mandurah Wreck trail. The wrecks are marked o

link with the past, our past. These vessels had an important
those who worked on them and those who were carried on them.

Leviathan 1921

Having foundered on a sand bar the remains of this ketch were once visible to divers two kilometres along the coast from Mandurah.

Orizaba 1905

The remains of the 3325 ton Orient liner comprise the largest and most spectacular wreck in the area. Somewhat amazingly, the the vessel was brought in over the 5 fathom bank in 1905, whilst under the mistaken belief they were heading for Fremantle. The coastline had been hidden by haze and a bush-fire. On realising his error, instead of stopping at anchor, the skipper strangely tried to repeat his feat by steaming back out again. Unable to repeat his good luck, the once fine vessel struck the reef and became a visible feature for many years. Over time it incurred heavy salvage.

Preston 1861

This schooner was just one year old when sailing from Fremantle to Port Gregory it ran ashore on the Abrolhos. Some months later it was refloated but in July 1861 it was wrecked in the mouth of the Murray River when the skipper ran it aground deliberately in an attempt to save it in a gale.

Robertina 1859

Leaving Fremantle with timber and goods for the Adelaide market, this vessel unexpectedly struck the Murray Reef. The twelve crew and seven passengers hardly had time to reach the boats before it sank. The remains of this 213-ton two masted brig were identified in 1987 by local diver Graham Anderton, when a bell bearing the inscription 'Robertina 1843', was recovered. Mr. Anderton recently donated the bell to the W.A. Maritime Museum in Fremantle.

Star 1880

The *Star* was a fine looking two masted schooner that carried a square foresail. It had been involved in arduous whaling operations, and was heading for Geographe Bay to re-commence the hunt on 28 September 1880. The captain was asleep on deck when, at 3.15 a.m., a member of the Malaysian crew yelled out 'Rocks to starboard'. The Captain had no success when he grabbed the wheel and the vessel swung round against the dangerous Murray Reef. As it ground against the rocks, the hull eventually gave way letting in water and it sank. In the following Inquiry, the unfortunate Captain was held responsible and his certificate was suspended for 18 months. The wreck was rediscovered in 1973, again by Graham Anderton and the Living Waters Skindiving Club.

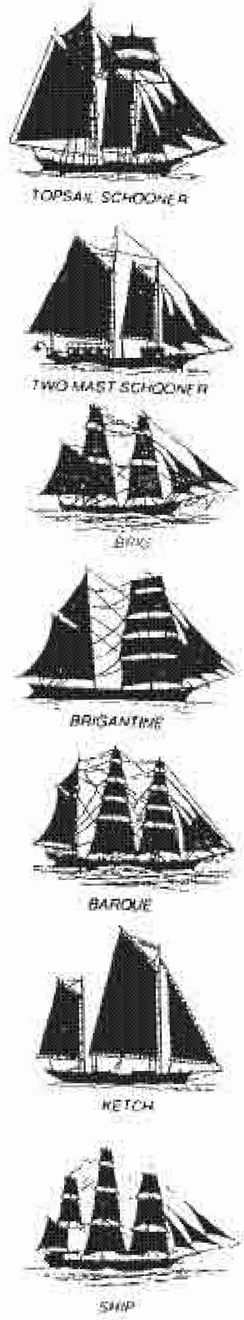
Star Queen 1878

On the night of July 29, Captain Henry Shelton, neglected to keep check on his vessel's distance from shore. It subsequently lost its rudder on the Sisters Reef. However, this story has a happy ending. Having been forced to discharge its cargo, it drifted inside the reef toward Long Point and laid anchor. Despite being towed to Careening Bay for repairs, it was sold early the next year by auction. Thus it continued a long career that had commenced in the builders yard at Kingsbridge, Devon in 1866.

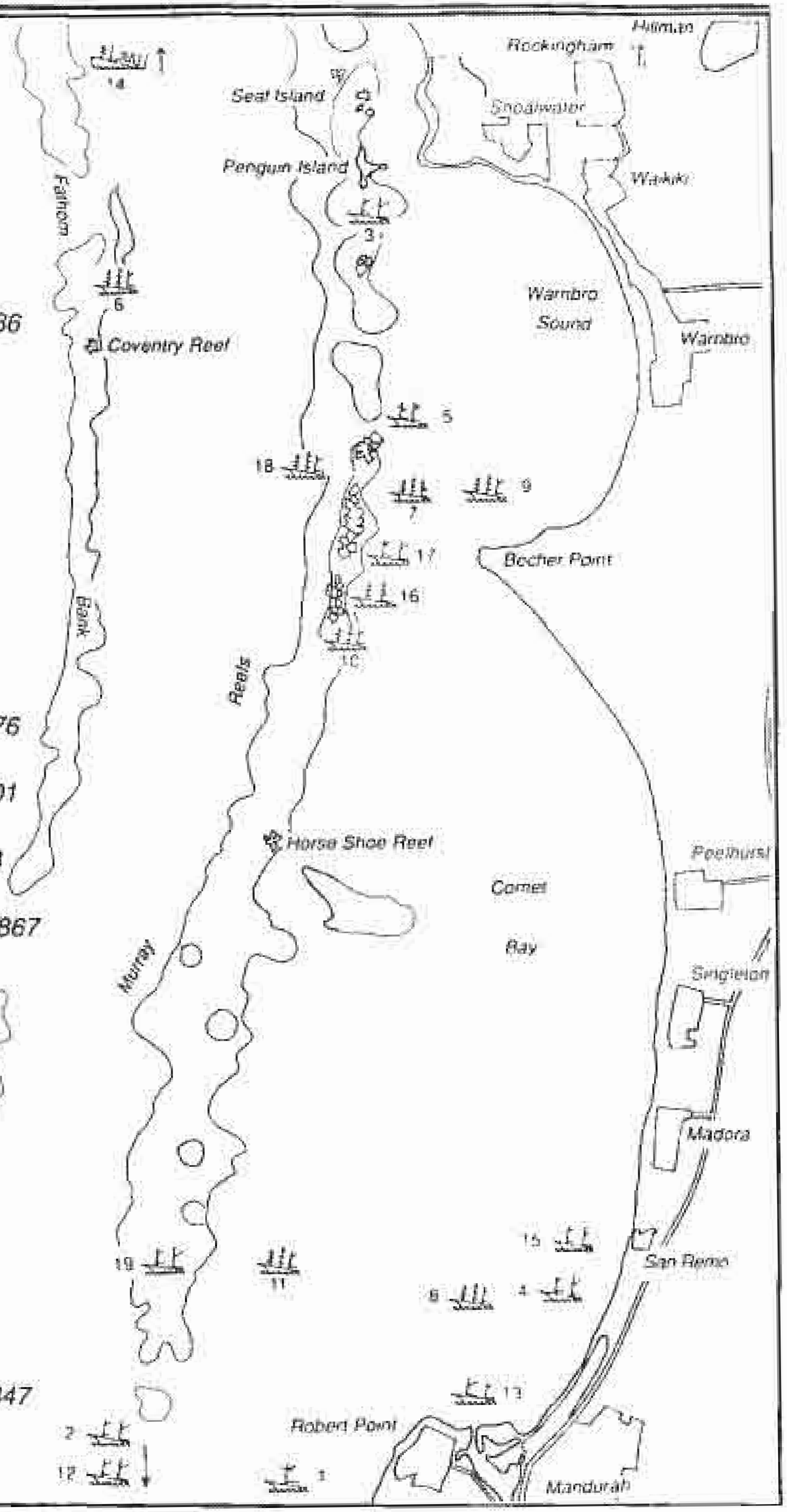
Young Shepherd 1847

On a voyage from Bunbury to Perth, this 15 ton schooner was lost. All crew and passengers escaped. The flour, butter and beef that comprised the cargo were recovered, but not the mail.

current charts and a pamphlet on the trail is available.



1. Alert 1875
2. Bee 1851
3. Belle of Bunbury 1886
4. Black Swan 1851
5. Bungaree 1876
6. Carlisle Castle 1899
7. Chalmers 1874
8. Coorong 1889
9. Hero of The Nile 1876
10. Highland Forest 1901
11. James Service 1878
12. Lass of Geraldton 1867
13. Leviathan 1921
14. Orizaba 1905
15. Preston 1861
16. Robertina 1859
17. Star 1880
18. Star Queen 1878
19. Young Shepherd 1847



THE MANDURAH WRECK TRAIL PROMOTIONAL BROCHURE.

Star*: This 69 ton wooden schooner struck the Murray Reef on October of 1880 after a whaling expedition. It went down with all its apparatus aboard. It was found $1^1/_2$ miles south of the Sister Rocks. The cargo salvaged. The *Star* was locally built in 1876. On board was John Bateman of Fremantle.

Star Queen: This 264 ton barque became stranded on the Sisters Reef. It later drifted inside the rocks and anchored at Long Point. After a few minor repairs, it was back on its voyages, never to interact with Mandurah's reefs again.

Hero of the Nile*: This 356 ton wooden barque sank at Long Point in October of 1876. Little can be seen today, as much of the wreck lies under sand and weed.

Bungaree: This 84 ton wooden schooner ran aground near the Sisters Reef, on the 13th of June 1876. Three minutes before it struck, the call went out of 'Breakers on the starboard bow'. The captain was unable to save the vessel and it went down at 0430 hrs. The 32 tons of tea, sugar, coconuts were lost, but luckily all the crew were saved. They were landed at Long Point, 2 miles from their wrecked vessel.

Chalmers*: This 606 ton British wooden vessel struck the Murray Reef on 19 March 1874 and was wrecked. Captain William Alexander was tried in court for wrecking the 3 masted sailing barque and his certificate was cancelled. He appealed without success, saying that he had seen a bushfire on the land and believed it to be light from Rottnest. The wreck can be seen by divers only about 4 to 7 meters down near the Sisters Reef.

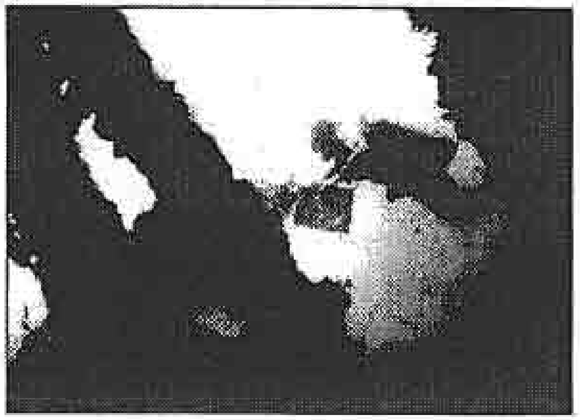
Highland Forest*: This 998 ton iron barque was totally destroyed on 29th April 1901, on a voyage from New York. Captain Alex Chapman, was unable to save the cargo of general goods. The wreck lies on the Murray Reef, 4 nautical miles south of Safety Bay. It eventually settled in $2^1/_2$ fathoms (c. 5 m) of water, about 4 miles from the shore and very close to the shallow reef. The well known author Joseph Conrad wrote one of his novels based upon his experiences on the *Highland Forest*.

Carlisle Castle*: This 1484 ton iron barque was lost with all hands on Coventry Reef in 1899. It was a major maritime disaster for Western Australia. The breakers on the reef should have been visible, but in the severe storm that led to the wreck they were not seen and the ship quickly went down. The wreckage lies on the northern end of the reef. It is a very popular dive.

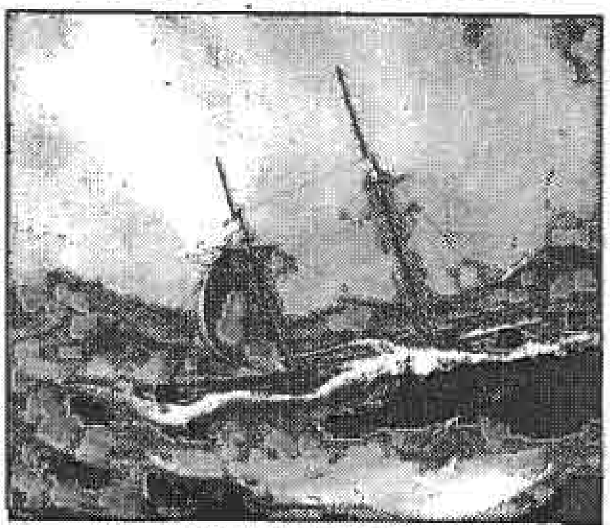
Robertina*: This 213 ton wooden brig carried a cargo of timber, flour and whale oil when it went down near Murray Reef on the 2nd of November 1859. It sank immediately leaving little time for the 12 crew members and 7 passengers to reach the boats. Captain Davis was charged for neglect of duty but was found not guilty in court. The cargo was sold at an auction.

Belle of Bunbury*: This 42 ton coastal schooner finally came to an end in December of 1886. It struck a rock just off Penguin Island and sailed only 80 meters before sinking in 3 fathoms of water, losing its 6 tons of potatoes and 70 bales of wool. No lives were lost.

Orizaba*: The remains of the 3325 ton Orient liner can be found west-north-west of Penguin Island. This is the largest and most spectacular wreck in the area. Somewhat amazingly, the vessel was brought in over the 5 fathom bank in 1905, in the mistaken belief they were headed for Fremantle. The coastline was hidden by haze and a bushfire. On realising his error, instead of stopping and anchoring, the captain elected to steam back out to sea and hit the reef on the way back out. The wreck stayed visible for a number of years and was heavily salvaged. It is a fascinating dive for the more daring.



The Mandurah Wreck Trail



The *Star* in heavy seas

SOUTH WEST DEVELOPMENT AUTHORITY

Western Australian Maritime museum

Text By Malcom Brooks
Harvey Agricultural Senior High School

Pamphlet Design By Ben Green
John Curtin Senior High School

Work experience students : WA Maritime Museum

How to get there.

Mandurah is located 30 nautical miles, about 60 kilometres, south of Fremantle, at the mouth of the Harvey River.

Introduction.

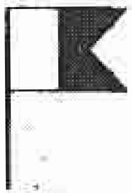
The aboriginal name originally given to the area was 'Mandjar' meaning 'trading place'. Aboriginals used to meet here and exchange tools and ornaments. The settler Thomas Peel adopted the native name which soon became changed to it's present form.

The location of Mandurah created many problems for early seafarers because of the nearby reefs and the sandbar at the mouth of the Peel Inlet. Using their primitive navigational equipment, it was no surprise to have several vessels being wrecked. Some of these ships have now been left in the oceans off our coasts for over a century, allowing them to be considered historic wrecks.

The WA Museum has responsibility to the community to protect and preserve these sites. Archaeologists from the museum often raise material from historic wreck sites, and treat them in the Museum's Conservation Laboratory in Fremantle. Eventually they are added to the museum's collection for research and display.

The Mandurah Trail was designed by the Fremantle Maritime Museum to allow the community to participate in enjoyment of Western Australia's historic background and to enhance awareness of it. It has been created with the assistance of the Mandurah Shire Council and the South West Development Authority. CALM assists by helping to manage the sites that lie in marine parks.

Please Note



- **Wrecks are often hazardous.**
- **Access to the wrecks requires a boat.**
- **Divers need to be fit and qualified.**
- **A diver's flag must be displayed**
- **Never dive alone or leave a boat unattended.**
- **Persons using this trail do so at their own risk.**
- **These wrecks are part of Western Australia's heritage. They are protected under legislation. Please enjoy them but do not disturb them.**

The Mandurah Wreck Trail

***Lass of Geraldton*:** This 32 ton wood coaster sank after capsizing just north of Mandurah on the 25th of March 1867. Four crewmen and two passengers died, including Mr. G. Shenton, the owner, Captain W. O'Grady and an Indian crewman were the only survivors who swam 7 miles to shore. After attempts to re-float the vessel failed, it was left to lie in 14 meters of water about 4 kilometres out to sea.

***Alert*.** This 19 ton cutter, bound for Fremantle, went ashore on the Murray Reef on the 28th of July 1875 and became a total wreck. The master of the vessel was John Kelly, and even though it was known that the bar was dangerous in winter, he was directed to make the crossing by the vessel's owners. He was later found guilty in court but no formal inquiry was held.

***Leviathan*.** This ketch was run aground on a sand bar in 1921. Its wrecked hull was visible to divers about 1½ kilometres off shore from Mandurah.

*The precise positions of these wrecks are known today.

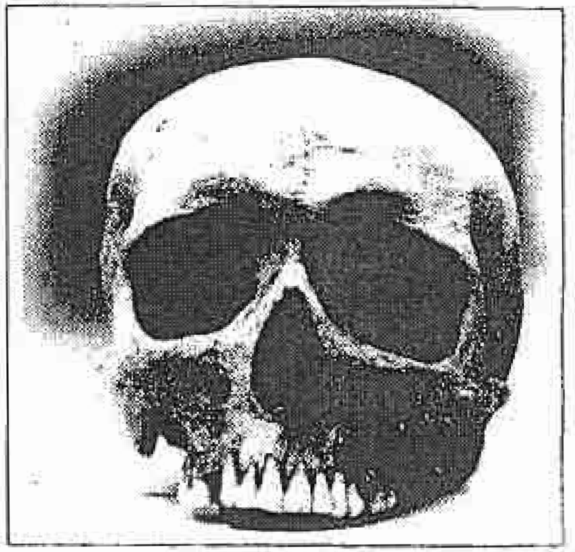
***Black Swan*:** This 14 ton cutter was reported lost in May of 1851. It ran aground on the Mandurah Bar carrying cattle from the farms of settlers around the Cape Naturaliste. This livestock was being taken to market at Fremantle.

***Coorong*:** This 369 ton barque was stranded on the Murray Reef in February of 1889, after a voyage from Adelaide. Captain Hayward was unable to see the land due to hazy conditions and grounded his vessel which was laden with general cargo. It was later re-floated and repaired.

***James Service**:** This 441 ton iron barque came to its tragic end on 23rd July 1878, on part of the Murray Reef. It settled in 2½ fathoms, on a reef which now bears its name. All hands were lost, including a theatrical troupe. Some bodies washed ashore and being greatly decomposed and disfigured, were difficult or impossible to identify. They were then buried in the sandhills close to where they were found.

The *James Service* is a horrific example of the dangers in the Mandurah area to the colonial ships. Below is the skull of one of the victims from the wreck.

***Young Shepherd*:** This 15 ton Schooner was lost on the 15th of May 1847 on a voyage from Bunbury to Perth. Luckily, all crew were able to escape the sinking ship. The cargo of flour, 600 kilos of butter and a cask of beef were all recovered, but the southern mail was lost.



THE MANDURAH ANCHOR PARK FORESHORE INFORMATION PLAQUES.

These anchors were supplied by
The Department of Marine and Harbours
and refurbished by
The City of Mandurah.
Though of 19th century design they have
been greatly modified and so are not
retained in their origional form.

An early iron stocked anchor. The sharp V and shape of the flukes are reminiscent of the early 18th and 19th century wooden stocked anchors. Contrast this anchor with the others nearby.

An iron stocked, Admiralty pattern anchor, from the wreck of the *James Service, 1878*. The gentle curve of the arms is reminiscent of the period. The welds can be clearly seen.

A Rodgers patent (small fluked), iron stocked anchor, with modification to enhance its holding capacity.

A late 19th century, iron
stocked anchor,
with widened flukes for
moorings
and harbour works.

HAMELIN BAY

The underwater wreck plinths for the Hamelin Bay Wreck Trail will be installed during December 1991. This has and will involve:

1. Design of a suitable Wreck information plinth that would require minimal resources to install it. This design is contained in Appendix II and has been submitted for publication in the AIMA bulletin.

2. Sourcing all construction materials required for the job, attempting to involve local firms in sponsorship by materials supply.

3. Having form-work made for the casting of the new style mini-plinth and subsequent casting of these by museum workshops.

4. Writing new text and compiling graphics for the new glass plaques, sourcing materials and printing as per Mandurah.

5. Organising all logistics for the journey south, including use of land cruiser, Starcraft and truck to carry materials.

6. Installing the new plinths as outlined in the paper submitted for publication (Appendix II)

7. Acquiring the G.P.S. co-ordinates and new transit photographs of each site.

THE HAMELIN BAY WRECK TRAIL UNDERWATER INFORMATION PLAQUES.

HISTORIC SHIPWRECK

AGINCOURT

BARQUE

THIS FINE, THREE MASTED, WOODEN BARQUE, OF 447 TONS WAS BUILT BY DOXFORD OF SUNDERLAND, NORTH EAST ENGLAND IN 1863, (AS WAS THE NEARBY *CHAUDIERE*). IT WAS APPROXIMATELY 43 METRES LONG WITH SUBSTANTIAL CARRYING CAPACITY FOR BULK GOODS SUCH AS TIMBER, ITS USUAL CARGO.

ON APRIL 18TH 1882, WITH A FULL LOAD AND AFTER BEING AT ANCHOR IN HAMELIN BAY FOR A PERIOD OF TWO MONTHS, A STORM AROSE ENDANGERING THE VESSEL. THE MOORINGS PARTED AND IT DRAGGED OVER THE REEF BEFORE BEACHING. AS THE CREW ESCAPED THE LONGBOAT CAPSIZED IN THE SURF, KILLING THE SHIP'S CARPENTER. THE *AGINCOURT* WAS THE FIRST OF A NUMBER OF VESSELS TO COME TO GRIEF IN THE BAY OVER THE NEXT TWENTY YEARS. IN THE SUBSEQUENT INQUIRY THE CAPTAIN WAS FOUND NEGLIGENT AND HIS CERTIFICATE WITHDRAWN FOR SIX MONTHS.

THE WRECK TODAY COMPRISES SHIP'S TIMBERS AND TIMBER CARGO THAT HAS BEEN WELL PRESERVED BY SAND COVER. BAMBOO CARGO MAY ALSO BE FOUND ABAFT THE REMAINS OF THE FOREPEAK BULKHEAD. YELLOW METAL SHEATHING AND BRONZE FASTENINGS LIE AMONGST THE HULL TIMBERS.

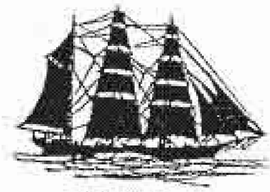
THE WRECK OF THE *AGINCOURT* IS A RELIC AND A REMINDER OF THE LOCAL TIMBER TRADE, AND THE DIFFICULTIES ASSOCIATED WITH THIS WORK IN TIMES WHEN MODERN FACILITIES DID NOT EXIST.

THIS WRECK IS AVAILABLE FOR YOUR EXAMINATION AND ENJOYMENT BUT HAS BEEN DECLARED HISTORIC AND PROTECTED FROM INTERFERENCE, UNDER THE PROVISIONS OF THE 1976 HISTORIC SHIPWRECKS ACT. FURTHER INFORMATION CAN BE OBTAINED ON THIS AND OTHER WRECKS AT THE W.A. MARITIME MUSEUM, CLIFF STREET, FREMANTLE.

Western Australian Maritime museum

HISTORIC SHIPWRECK

CHAUDIERE



BARQUE

A COMPOSITE WOODEN BARQUE THAT LIKE THE NEARBY *AGINCOURT*, WAS BUILT BY DOXFORD OF SUNDERLAND, NORTH EAST ENGLAND IN 1863. COMPOSITE CONSTRUCTION MARKS AN IMPORTANT TRANSITION BETWEEN WOOD AND IRON AND IS SHARED WITH SUCH FAMOUS VESSELS AS THE CHINA TEA CLIPPERS, *CUTTY SARK* AND *THERMOPYLAE*. IT HAD A GROSS TONNAGE OF 470 TONS, WAS APPROXIMATELY 45 METRES LONG AND WAS INVOLVED IN THE TIMBER TRADE THAT WAS VITAL TO THE SOUTH WEST OF WESTERN AUSTRALIA.

WHILST AT ANCHOR ON JULY 26TH 1883, THE VESSEL STARTED TO DRAG ITS MOORINGS. WHEN HULL DAMAGE OCCURRED AND FLOODED IT'S HOLDS, IT WAS BEYOND SAVING AND THE SAILS WERE UNFURLED TO DRIVE IT FURTHER ASHORE. THE LOSS ADDED TO THE CONTROVERSY OVER THE SAFETY OF THE PORT. SOON AFTER, A HARBOUR MASTER WAS APPOINTED TO ORGANISE THE SAFE ANCHORAGE OF VESSELS AND GIVE STORM WARNINGS.

AMONGST THE WRECKAGE YOU MAY SEE DISTINCTIVE CRISS CROSS IRON HULL AND DECK BEAMS, UNIQUE TO COMPOSITE VESSELS, AND COPPER ALLOY HULL SHEATHING. OTHER ITEMS COMPRISE DECK WINCHES, TIMBER CARGO AND IRON DECK FITTINGS.

THE WRECK OF THE *CHAUDIERE* IS A RELIC AND A REMINDER OF THE LOCAL TIMBER TRADE, AND THE DIFFICULTIES ASSOCIATED WITH THIS WORK IN TIMES WHEN MODERN FACILITIES DID NOT EXIST.

THIS WRECK IS AVAILABLE FOR YOUR EXAMINATION AND ENJOYMENT BUT HAS BEEN DECLARED HISTORIC AND PROTECTED FROM INTERFERENCE, UNDER THE PROVISIONS OF THE 1976 HISTORIC SHIPWRECKS ACT. FURTHER INFORMATION CAN BE OBTAINED ON THIS AND OTHER WRECKS AT THE W.A. MARITIME MUSEUM, CLIFF STREET, FREMANTLE.

Western Australian Maritime museum

HISTORIC SHIPWRECK

KATINKA

BARQUE

THIS GERMAN BUILT, IRON HULLED, THREE MASTED, BARQUE WAS ONE OF FOUR SHIPS WRECKED IN HAMELIN BAY ON THE NIGHT OF THE 22ND JULY 1900. AT 843 TONS AND OF 65 METRES IN LENGTH IT WAS THE LARGEST VESSEL TO VISIT HAMELIN BAY.

AS NORTHWESTERLY WINDS STRENGTHENED, IT CAST OFF FROM THE KARRIDALE JETTY FOR SAFER MOORINGS. A HOWLING HURRICANE AROSE THAT NOT ONLY WRECKED SHIPS BUT DAMAGED COMMUNICATIONS, TREES AND HOUSES.

THE *KATINKA* PARTED ITS CABLE ON THE OUTER MOORINGS AND STRUCK BOTTOM 500 YARDS FROM SHORE. FIVE CREWMEN DROWNED, INCLUDING THE CABIN BOY AND THE REMAINING NINE ONLY SURVIVED BY SWIMMING TO SHORE OR CLIMBING THE FOREMAST.

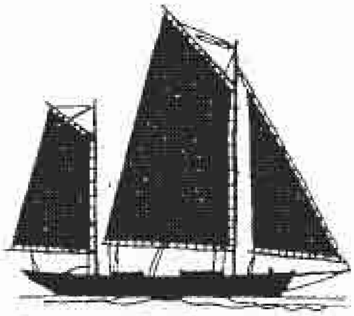
THE REMAINS OF THE CLIPPER BOW LIE ALMOST UPRIGHT WITH THE IRON BOWSPRIT STUB STILL ATTACHED. OFF THE SEAWARD SIDE IS THE HEAVY ANCHOR WINDLASS. THE STERN IS ON THE GENERAL AXIS OF THE WRECK BUT TURNED SLIGHTLY TO SHORE. HULL FITTINGS, BOLLARDS AND WINCHES MAY BE FOUND BUT SEASONAL SAND BUILD UP MAY HIDE PARTS OF THE WRECKAGE.

THIS WRECK IS AVAILABLE FOR YOUR EXAMINATION AND ENJOYMENT BUT HAS BEEN DECLARED HISTORIC AND PROTECTED FROM INTERFERENCE, UNDER THE PROVISIONS OF THE 1976 HISTORIC SHIPWRECKS ACT. FURTHER INFORMATION CAN BE OBTAINED ON THIS AND OTHER WRECKS AT THE W.A. MARITIME MUSEUM, CLIFF STREET, FREMANTLE.

Western Australian Maritime museum

HISTORIC SHIPWRECK

TOBA



Ketch

THE *TOBA* WAS A SMALL VESSEL OF ONLY 15 TONS, BELIEVED TO HAVE BEEN BUILT IN THE DUTCH INDIES IN 1907. VERY LITTLE IS KNOWN OF THE HISTORY OF THIS VESSEL BUT IT IS THOUGHT TO BE A KETCH RIGGED LUGGER.

THE PRECISE DATE OF ITS LOSS IS ALSO NOT KNOWN BUT MAY HAVE BEEN AROUND 1945.

VISIBLE REMAINS ARE TIMBER FRAMES AND A SMALL ANCHOR WINCH.

AN ORNATE BINNACLE IS ON DISPLAY FROM THE WRECK AT THE AUGUSTA MUSEUM.

THIS WRECK IS AVAILABLE FOR YOUR EXAMINATION AND ENJOYMENT BUT HAS BEEN DECLARED HISTORIC AS PART OF THE HAMELIN BAY WRECK TRAIL. FURTHER INFORMATION CAN BE OBTAINED ON THIS AND OTHER WRECKS AT THE W.A. MARITIME MUSEUM, CLIFF STREET, FREMANTLE.

Western Australian Maritime museum

APPENDIX ONE

Projected timetable for completion of plinth installation.

November 23rd. and 24th.

Buoy and G.P.S. remaining Mandurah sites.
Assess potential locations for plinths.

November 30th. and December 1st.

Install Mandurah plinths.

December 2nd. to 6th.

Construct Mini-plinths and prepare materials at Cliff street workshop.

December 7th. onwards.

Buoy and G.P.S. sites.
Install Hamelin Bay plinths.

The timetable will vary according to weather conditions.

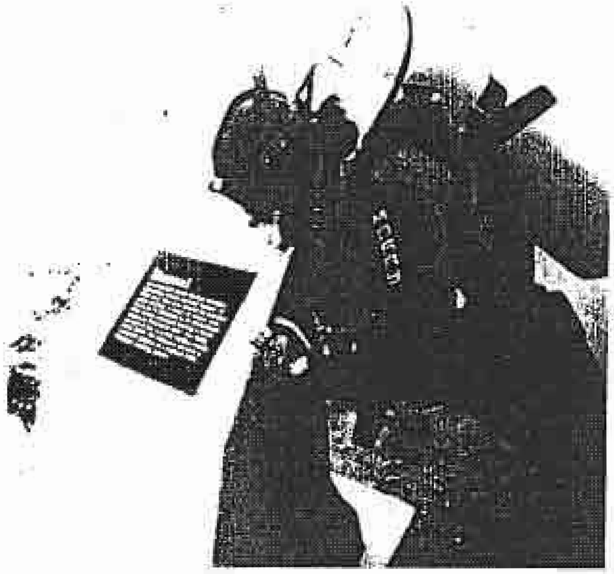
APPENDIX TWO

Proposed Aima bulletin article on new wreck plinth design.

Wreck trail identity plinths, a proposed new design for the Hamlin Bay Wreck Trail requiring minimal resources

Ed Punchard

This paper proposes a new design of wreck trail plinth. It discusses materials, installation and aesthetics. Earlier designs are also examined with particular regard to durability.



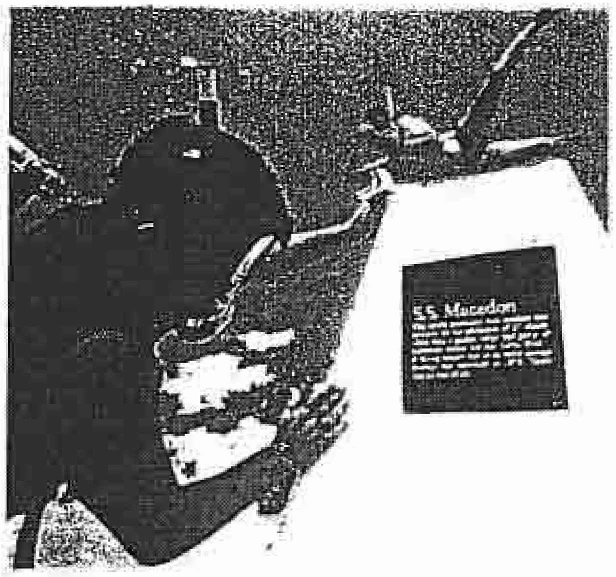


Photo : B. Jeffery *Photo : W.A.M.*

Figure one. Examples of existing wreck trail plinths on the Adelaide and Rottnest Wreck trails

Introduction

A few month ago I witnessed the consternation of a number of my colleagues when weather ruined their attempt to install a series of plinths for a particular wreck trail. They were many miles from their home base and they had put great effort in forward planning of construction and logistics. I was struck by the need to avoid such a loss of resources. Considerable efforts are required for such projects and to see them scotched with their vessel trapped away from its home port would have been frustrating and costly. With the need for efficiency in all publicly funded activity likely to increase rather than decrease in the economic environment, we all have a responsibility to make the most of facilities available to us, especially where establishing hard fought for new schemes.

Within a few days a discussion took place with myself and Mike McCarthy (Department of Maritime Archaeology, W. A. Maritime Museum) concerning this. The possibility of a new design of wreck plinth that would require fewer resources was suggested by him. Having a background of commercial diving and engineering I made some suggestions. Our conversation identified potential for a particular approach and this paper explores that.

Basically we felt that there should be a simple alternative that would avoid even the possibility of the problems that had been encountered and so my investigations commenced.

I started by examining the plinths for already established wreck trails. I found information and pictures of a number of different designs and dived a series of wrecks where they are installed. They all looked big, shiny and expensive, so certain issues came to mind.

They all require substantial facilities in their installation due to weight and size. Such facilities are expensive especially if they cannot be efficiently used due to weather problems.

Some believe their appearance is intrusive. This is often intended so they are easily found but it is doubtful whether it is necessary for them to take on the direct appearance of a traffic bollard. They could hardly be said to blend in with their environment. Anti-fouling paint had been applied to a number of them to stop colonisation of their surface by the marine life. Does this create the right blend for the aesthetics of the wreck environment?

Another issue was the difficulty of installing concrete blocks on some seabed topography. A whole variety of seabed conditions may be unsuitable for concrete blocks and even preclude their use, such as a complex reef structure.

After consideration I sketched a series of designs in an attempt to solve the problems in the simplest way. A variety of ideas came to mind to lighten the structure and ease the load on installation facilities. Consideration was given many designs but one of the simplest of underwater construction techniques seemed a clear winner and that was; concrete bag-work.

The proposed new design and its installation

Concrete bag-work has been used by divers in harbour repair work and the underwater civil engineering business for years. It is simple, well proven and effective. It has the advantages of simplicity and availability using the most basic of materials; Hessian bags, dry cement mix and sharpened reinforcement bars.

These can be facilitated with local resources virtually anywhere, removing the need to carry large preformed plinths around the country. The construction is done in situ, and with the scale required for wreck trail plinths, each site can be completed in a short time by one or two divers, depending on the water depth.

The diagram below shows the main features of the plinth. They comprise a reinforcement mesh base, a connected anchor bar with threaded upper end, cement filled Hessian bags and a miniature plinth screwed onto the anchor bar with a separate internally threaded retaining eye.

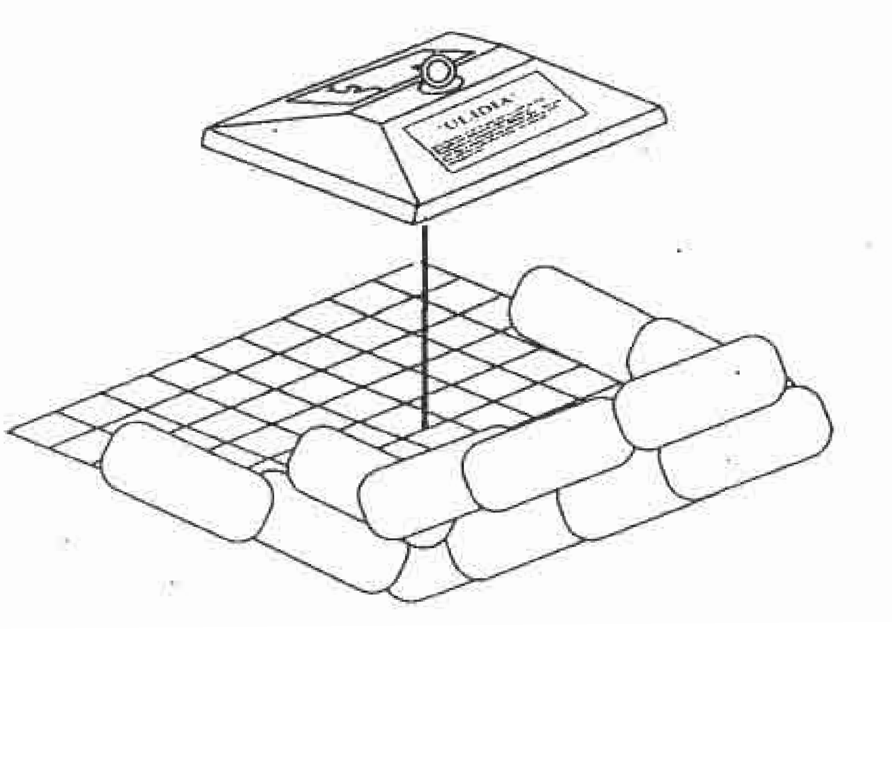
Construction method

The construction method requires the bags to be filled with dry cement and sand mix. The combination should be rich in cement, up to 4:1, to allow for some 'wash out'. These are lowered to the diver at the desired plinth site, after the mesh base and threaded anchor bar have been installed. The diver then constructs a pyramid of bags on top of the base to form the plinth.

During the laying operation the diver hammers sharpened reinforcement bars through the bags pinning them together. Initially these penetrate both the first layer of bags and the seabed below to create extra anchorage. As the pyramid builds up in layers, the diver hammers the bars through the layer he has just placed into the layers of bags below. In this way the bars form the reinforcement of the structure which becomes very strong.

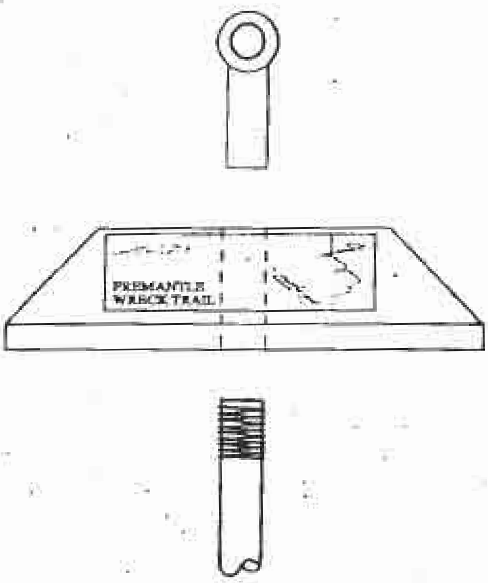
With the pyramid completed the threaded end of the anchor rod protrudes from the top and the structure is ready for the mini-plinth.

figure two Isometric view of the proposed new plinth showing main construction features



This is then lowered and the central hole placed over the threaded anchor bar. The retaining eye is then screwed down with a tommy bar to compress the bags and firmly secure the mini-plinth.

Figure three. Mini-plinth showing retaining eye and threaded anchor bar as used for attachment to the newly built bag work pyramid



The Mini-plinth

The mini plinth is the mounting for the information plaques that is screwed onto the threaded end of the bag-work pyramid. The 'mini-plinth' can be of a variety of designs. The suggested one here is flat and twin sided but a three sided or square pyramid would also be quite satisfactory, depending on specific preferences, amount of information space desired and local seabed conditions such as swell (a low profile plinth suffers less force). For our purpose the essential feature of the mini plinth is its size at no more than that required to carry the glass information plaques.

The mini plinth is designed to be pre-formed of concrete poured as a slurry into a glass fibre or similar mould. This is a process that can be quickly repeated and if necessary can be undertaken on site. Within the mould should be placed a simple steel mesh that the slurry combines with to create a reinforced concrete item. Attached to this should be a tube that will allow the threaded anchor bar to penetrate. In installation the tensioning eye can then slide into the upper part of the tube and be screwed down the compress the bag-work pyramid together.

Advantages of the system

Having examined a number of designs including those for The Rottnest Wreck trail, The British Columbia Underwater Archaeological Society, The Adelaide Underwater Heritage trail and The Victoria Wreck trail, emphasis in the past seems to ave been on high profile, large, heavy pre-formed concrete blocks of a variety of design.

Their presence on the site, whilst intentionally easy to locate, could be regarded as intrusive to the established marine life of the wrecks which themselves almost always appear as a fully blended part of the seabed vista. Concrete bag-work with its irregular, rugged appearance will quickly transform itself into a part of the scene with life colonising the irregularities of its surface. This irregular and more natural appearance can also be enhanced by constructing nooks and crannies or incorporating loose rocks from around the site during the construction.

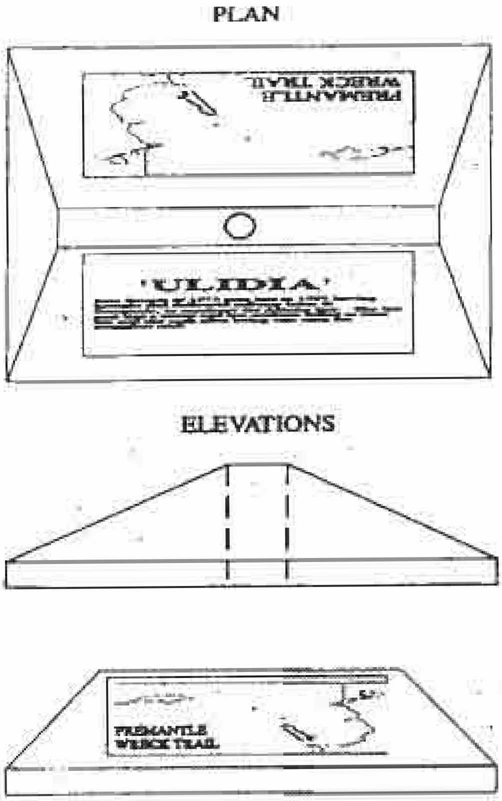
The seabed at the plinth site does not have to be of a regular flat type for this design. Any seabed will accept a bag-work construction, and often plinths could be incorporated into the irregularities of a reef to further minimise the intrusion. Almost any shape can be adopted for the bag-work even as far as filling a hole in the side of a reef. The important part is the reinforcement of the bag-work for strength and the inclusion of the anchor bar, (whose shape can be changed accordingly) for the attachment of the 'mini-plinth'. The tensioning eye can also be used to buoy the wreck. This is quite acceptable during the summer season and allows divers to travel straight to the information plaques, a good way to start a dive.

Perhaps the most clear advantage of this proposed design lies in the absence of major support facilities. This will bring associated savings in manpower, materials and fabrication costs. Expensive construction by contractors can be dropped. Large hard boats with cranes or 'A' frames are unnecessary. A small diving team is sufficient with a zodiac as perhaps the largest piece of equipment required. Other than that, only a few lines are needed for the construction of the plinth, plus some minor tools such as a lump hammer for piling the bars through the bag-work. Materials can be sourced in the local area of the wreck trail. The bags can be filled onshore then loaded in sufficient quantities for each individual job. Once on site these are lowered to the diver by work line in a rope net or old mail bag. Providing the Hessian is not of very loose weave there is no possibility of the cement 'washing out' of the dry mix. As the setting of concrete is a chemical, not drying reaction, then within a few hours of immersion the bag-work structure will be solid.

The information plaques.

Wreck plinths undoubtedly provide interest to divers on the site. Often Scuba lovers will have no real historical sense of what they are looking. It is important that if we take the trouble to provide text that is sufficiently informative.

Figure four. Mini-plinth showing information plaques



Whilst divers would not expect spend much of their wreck dive reading, perhaps as much as a minute is not excessive and thus a good amount of information should be provided. Overcrowding the plaque can be a problem, the plaque has to look right to attract interest. However, graphic information is good. A logo of the vessel type will add to interest, attractiveness and be informative. Therefore graphics are important, how many divers actually know what a three masted barque is? If two or more plaques are on the plinth then so much the better. Perhaps the best use of the additional plaque would be to provide a wreck site map. This would show all important features in relation to the position of the plinth. Many divers visiting a wreck site for the first time find the experience a bit bewildering. A plan would enable the diver to understand what he or she was seeing far better and add to their enjoyment. In this way museums and archaeologists can be seen to give back to sports divers rather than just restrict them.

Also it should not be forgotten that when dealing with a historic resource we have to protect it. A gentle reminder of the responsibilities of a diver in not 'souveniring' may just make the difference to someone who's sensibility could be overcome underwater in the heat of the moment.

Examples of the plaques produced for the Mandurah Wreck Trail are shown in appendix one.

Discussion of materials for wreck plinths

Having discussed the design aesthetics and possible advantages of the construction method there are somethings that we must not overlook. In particular whether the new design be durable enough for its purpose and how will it compare with the other standard surface built concrete blocks.

This latter section deals exclusively with this and asks: will ancillary materials be satisfactory, what is an acceptable design life, what are the destructive influences, how can they be detected and how can they be combated?

Ancillary materials

Some materials are consistent between designs. A minimum of 10mm glass is recommend, cut 10mm smaller all around than the plaque recess, to allow for error or inconsistency in the moulding. Sikaflex silicon base adhesive is well tryed and tested and should provide excellent results. Commercially screen printed text employs good durable paints and these can immediately be backed with a thin layer of sikaflex to provide protection, colour contrast and a good base for the adhesive when installed in the plinth.

Acceptable design life

A nebulous issue. Harshness of site conditions, likelihood of future funding, possible changes in the promotion of such sites necessitating new plinths and the durability of component items all play a part. In this case then we must be to an extent arbitrary. Fifteen or twenty years seems reasonable against the destructive forces of the sea and concrete corrosion. Concrete corrosion is our main worry and we should consider it with this period in mind.

Forces of the sea

Whilst a wreck plinth is not a structural item it will suffer the considerable forces of the ocean. For example, the Sirius wreck plinth was washed over like tumble-weed from its shallow site into a gully (Pat Baker personal, communication). The new design is intended to be as heavy as the solid blocks and have the advantage of being able to be pinned down to seabed features with the reinforcement bars.

Concrete corrosion

Basically this is the corrosion of the steel within the concrete structure and the damage that stems from this. In normal conditions the steel reinforcement, usually in the form of bars or mesh, is maintained in a passive state owing to the highly alkaline environment created by the constituent materials of the concrete. The major constituents of Portland cement are C3S, C2S, C3A, C4AF. Minor ones are MgO, TiO_2, Mn_2O_3, K_2O and Na_2O. The later two are known as the

Alkalis. Ca(OH)2 with KOH and NaOH gives the solution a very high pH of 12.4 and it is this that creates the normally passive environment for the steel.

In civil engineering their have been a number of significant failures involving structural use of reinforced concrete due to concrete corrosion. These have included losses of bridges and buildings. Studies resulting from these incidents have given a good understanding of this corrosion and we can draw on these to asses our own requirements.

Previous studies have shown that the problem is the deterioration of the steel reinforcement itself and that this can set in within the first decade (Midgley, 1973). The aggressive agents that led to the corrosion of steel normally include moisture (or another form of electrolyte), oxygen, certain ions and suitable pH conditions. Clearly in normal conditions these agents will be precluded from the steel.

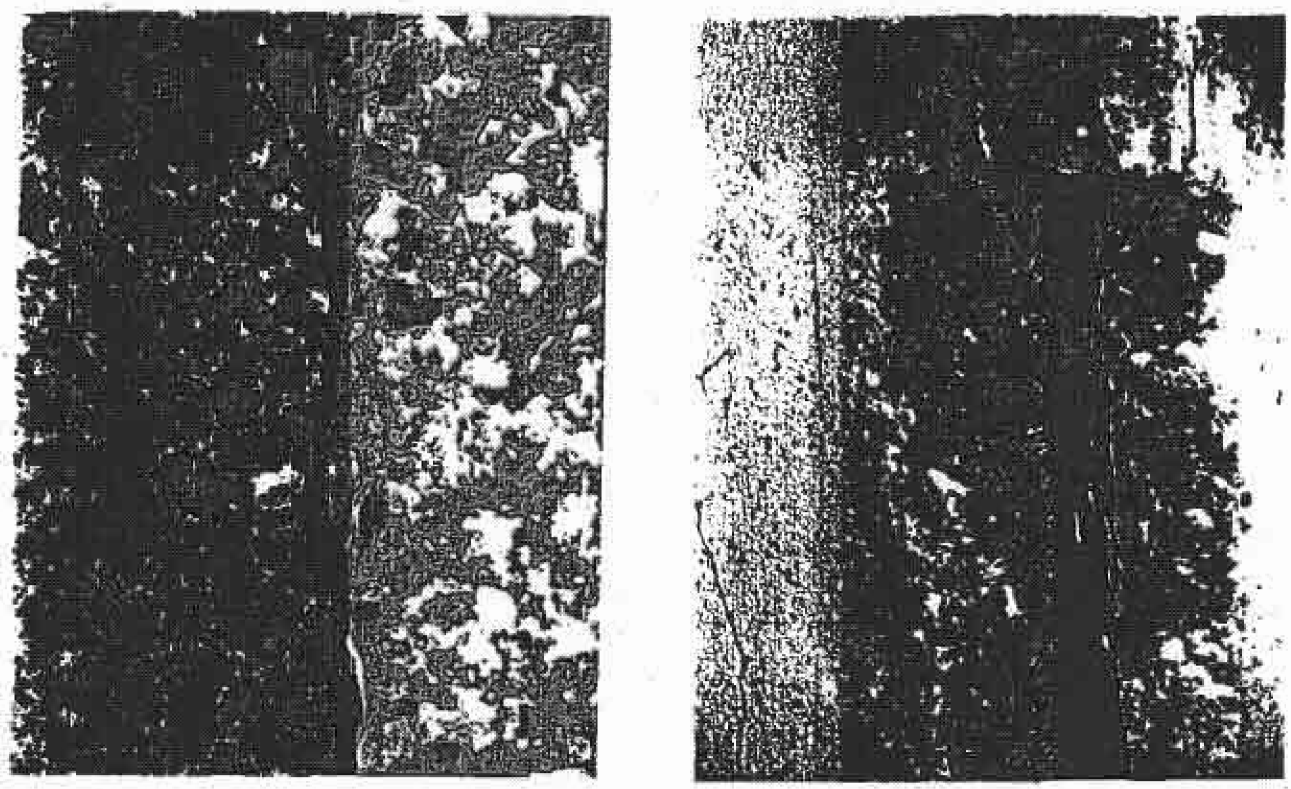
In conditions where aggressive agents are prolific failures are far move common. Indeed some of the more serious engineering failures in the USA and UK have been linked with the use of de-icing salts on bridge decks of roads and freeways or air borne salt sprays causing balcony failures in Sweden (Stratfull, 1957, Schell, 1986 and Svensson, 1979). Thus consideration of concrete corrosion within the marine environment is important.

Adverse mediums surrounding the concrete reinforced structures are not enough alone to create the failures however. Their are enough large concrete structures immersed in sea water (including some 1500ft. oil rigs) to testify to appropriate techniques combating these conditions. Therefore, as well as the surrounding environment, a means must also exist to enable the aggressive agents access to the steel work. This can only be by a few means; Gaps exposing re-bars, cracking, porosity and diffusion through the concrete.

i) Gaps
For the new design this is a potential Achilles heel. Despite the efforts within the design to see the pyramid compact together with hammered re-bar and screwed down mini plinth, it seems likely that in places gaps will remain between bags or along bars. These would not exist in a poured concrete block. This will allow water ingress and corrosion to the bars. A solution will be addressed later.

ii) Cracking
'Plain reinforced concrete, is much more susceptible to cracking during curing than prestressed concrete' (A.S 1480. 1982). The surfaced poured blocks are not stressed at all but a lesson is available

Figure five, Concrete corrosion resulting from airborn chloride attack on Cottesloe beach fencing



from the studies into this. Further research reveals that it is due to the majority of non prestressed concrete being poured on site where control of conditions is more difficult. Prestressed concrete is more likely fabricated within works where conditions are easy to monitor (B.W.Cherry and M.L.Allan 1987). The lesson is that conditions must be checked and standards followed for block pouring. Correct mix and distance between the re-bars and the outer face are uppermost, though shrinkage in curing is also an issue. Considering these studies highlights the possibility of problems for the proposed new plinth where the whole curing process is a shambles of individual bags setting at different times, probably with varying water content.

iii) Porosity:
The cement reacts with the water when mixed and hardens through a chemical reaction. Calcium silicate hydrate (Tobermorite gel) is responsible for the cementing action (Cherry and Allen 1987). It is rigid but within it there exist interstitial voids known as gel pores. Capillary pores are much larger, are interconnected and give rise to permeability and inhomgeneity with the concrete (Cherry and Allen 1987). The water that exists within the pores is generally high pH and protective as mentioned earlier. However, research has shown that diffusion of carbon dioxide dissolved in water can penetrate the concrete. Carbon dioxide reacts with the Calcium hydroxide in the concrete to form Calcium carbonate which has a neutral pH value. Thus the process reduces alkalinity and shifts the position of the steel on the Pourbaix' diagram from the passive zone to the active zone. Similar diffusion of chloride ions accelerates the effect further.

The problems above indicate how the water can ingress and start corrosion. The kind of corrosion that takes place may vary. Corrosion occurs on the loss of passivity. Chlorides will reduce resistivity and the inhomogeinous nature of concrete will vary chloride concentrations and create differential cells. Crevice corrosion will occur as the reaction effects the micro-environment within an enclosed space. Sulphate attack may occur with burial and cause swelling and damage to the concrete, exposing the steel to more aggressive sulphate attack and pitting corrosion. Pitting corrosion could also result from differential aeration within the plinth structure particularly the with new design. Difference in oxygen concentration would result in regions of lower concentration becoming anodic and at the higher concentration cathodic

Conclusions

These issues are interesting and an understanding of them is important when considering plinth choice. On balance they appear to indicate that the old solid block design is more durable and should remain for a satisfactory period underwater without requiring replacement.

Conversely it is clear from these issues that the bag-work design will likely be less durable. If the reinforcement bars suffer corrosion, break up of the block could occur.

Does this mean that the new design is unsuitable for use? The answer is no. Bag-work construction is a well tried technique for repairs to bridge footings harbours and other underwater structures. It is regarded, if not permanent, as effective in the mid-term. It's durability can be extended to guarantee life for our purpose by simply using galvanised steel in the specification and ensuring tight compacting in the construction. The design is intended to force the bags together strongly with the re-bars hammered in tightly and the mini-plinth screwed down. It is fair therefore to expect that by using galvanised components that these plinths will perform well within the expected parameter of fifteen to twenty years. Of course experience will tell but in the meantime the bag-work plinth is potentially an effective means to avoid wasted effort and resources on installing wreck trails away from home base.

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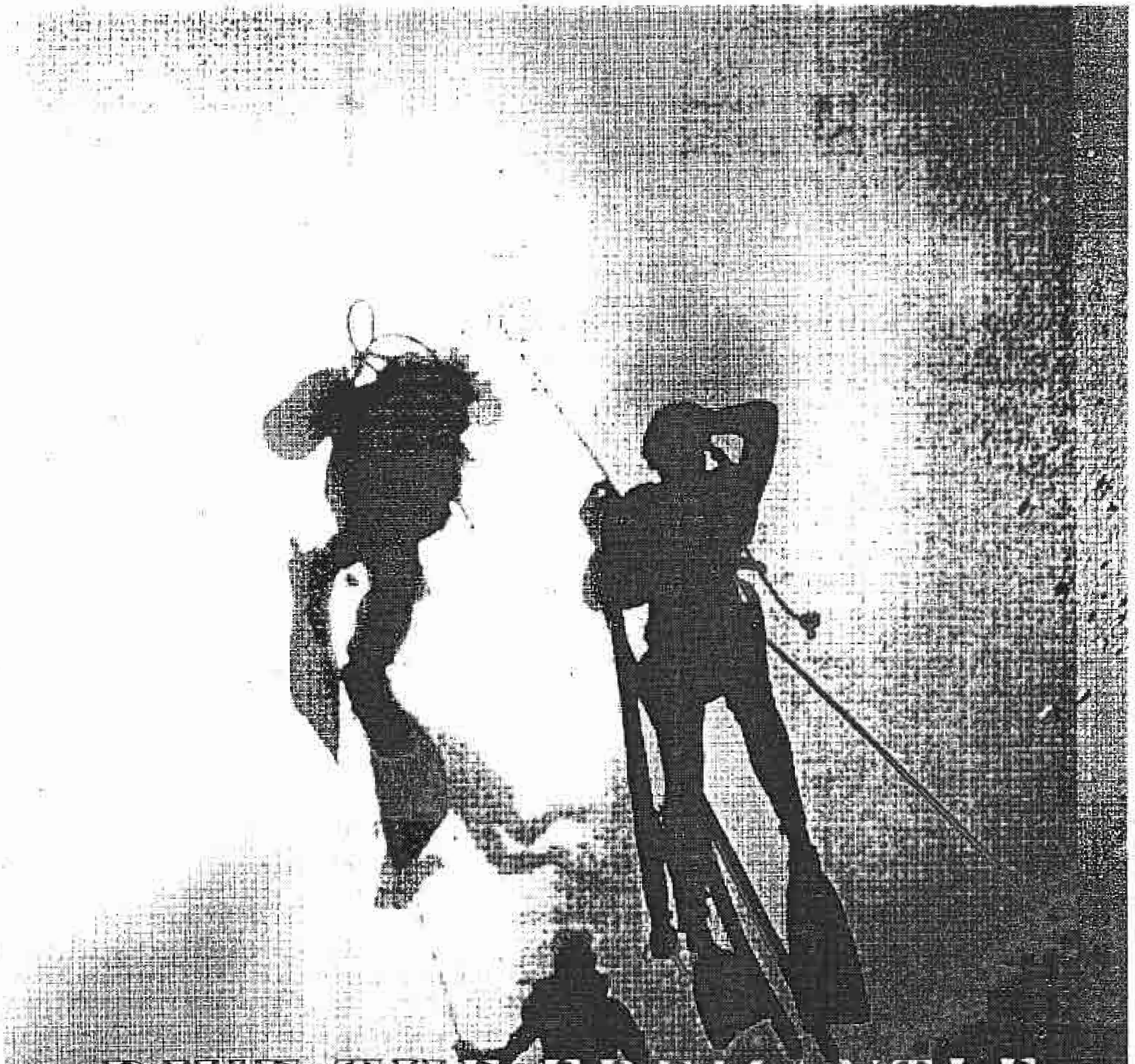
APPENDIX THREE

'Dive Freo'



DIVE THE FREMANTLE WRECK TRAIL !

THE W. A MARITIME MUSEUM IN FREMANTLE IS PROMOTING WRECK DIVING IN THE FREMANTLE AREA WITH TWO NEW SCHEMES, THE FREMANTLE WRECK TRAIL AND THE WRECK DIVERS PASSPORT.

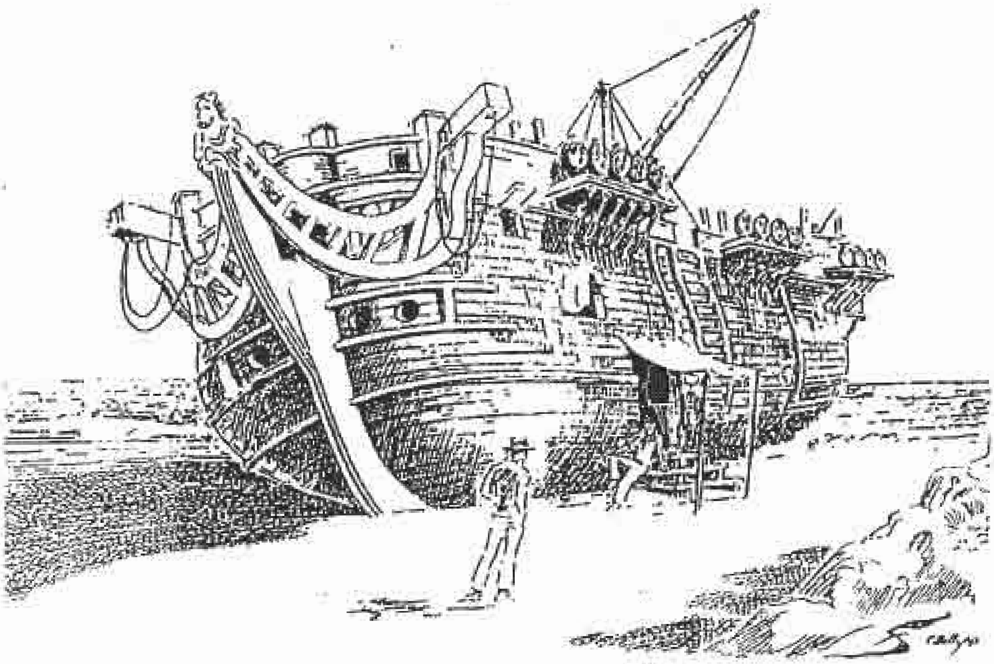
WHY IS FREMANTLE SPECIAL FOR WRECKS, AND WHY SHOULD A MUSEUM ENCOURAGE DIVING?

CLEARLY THERE IS MORE TO THIS THAN MEETS THE EYE!

The Dutch may have found the west coast of Australia first but it was for England and King George that Captain Charles Fremantle claimed in 1829, what was to become an important town and harbour. The settlement at the river mouth was to take his name whilst inland the now capital city of Perth was founded.

Equally, whilst the Dutch were responsible for some of our finest shipwrecks, the colonial period saw far more ships wrecked and many around Fremantle itself. Perhaps the very first, the *Marquis of Anglesea* even became the governors original residence in Fremantle!

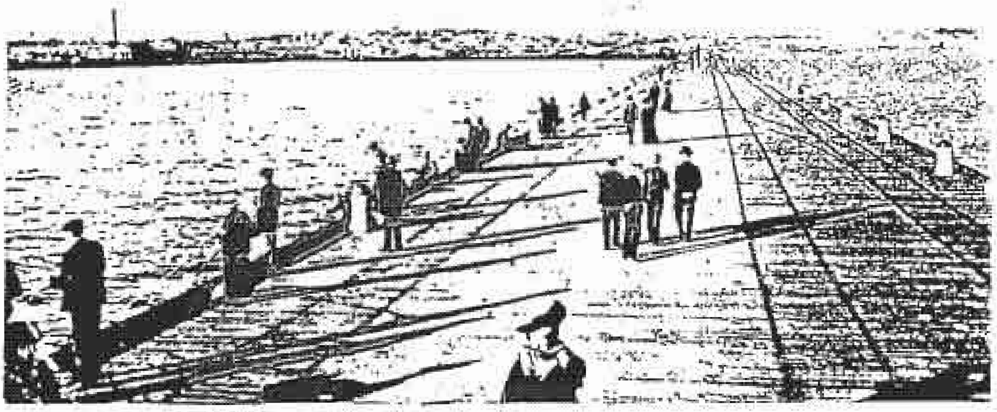
The hulk of the Marquis of Anglesea. An artists impression of how it may have looked at the time.



The *Marquis of Anglsea* is long since buried under the south mole but many other early voyagers to the colony found the place a bit exposed. The limestone reef across the mouth of the Swan River stopped settlers and traders in large vessels from using its shelter. They needed a mooring place and so the site of the modern fishing harbour became the rather open anchorage for the small fleets of visiting ships.

This situation did improve with the building of the Long Jetty out from bathers beach in 1873, but it took C.Y. O'Connor, engineer extaordinaire, to provide the river mouth harbour in 1897. Deepened and improved over the years this is the modern port facility we know today.

The Long Jetty, the first real haven for Fremantle shipping and later on a popular Sunday afternoon stroll.



Until this some of the larger ships preferred to use Albany with its fine natural harbour but many did not, and so encountered landfall on a difficult coastline that could unleash punishing forces.

Islands, reefs, uncharted rocks, and poor navigational aids all played their part in the fate of many colonial period ships within sight of their destination. So many voyages from often far away lands ended disastrously. At the time of these losses the papers of the day carried news with sad regularity and campaigns began for improvements. This ultimately led to the new harbour.

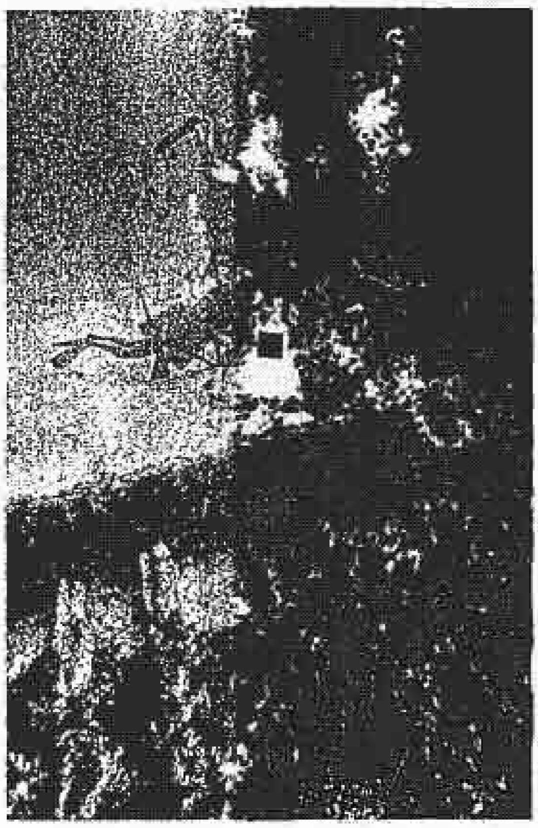
It may well be that this was all driven by the commercial needs of a new colony that could ill afford the loss of important cargoes, rather than philanthropy and care for lost souls. Whatever the motive, the new facilities did transform Fremantle and make it a safer place to visit and develop the colony's economy. After all, the loss of a valuable cargo to a young settlement hit merchants and consumers alike. Many of the lost products were totally unavailable locally. Farmers needed tools, miners explosives and railways machinery. Everyone was to loose, except of course the modern sports diver.

As time passed on the seabed, the bones of the sailors were joined by the bones of the ships. Natural forces steadily broke the once fine vessels apart, but there was another effect. Just as the sea destroyed the ships in their last moments, stripping them of their dignity and turning them into underwater scrap heaps, it was eventually to preserve and hide their final remains.

They were certainly largely out of sight and out of mind, until of course the invention of the aqualung and the advent of scuba diving at about the time of World War II. The wrecks lay relatively still and their secrets were often locked inside them, waiting to be discovered by the new breed of explorers and pioneers, underwater ones.

The catalogue of shipping loss around Fremantle now provides hours of fascination and entertainment for sports divers. Many have been diving these wrecks for some time, and the sport is booming with many novice divers training each year in one of W.A.'s many scuba schools. Now the staff of the Maritime Museum in Cliff street Fremantle have compiled a Wreck Trail for the area and are installing seabed information plinths to add to the enjoyment of these wrecks.

Divers examining the Plinth for the Lady Elizabeth, part of the Rottnest Wreck Trail.



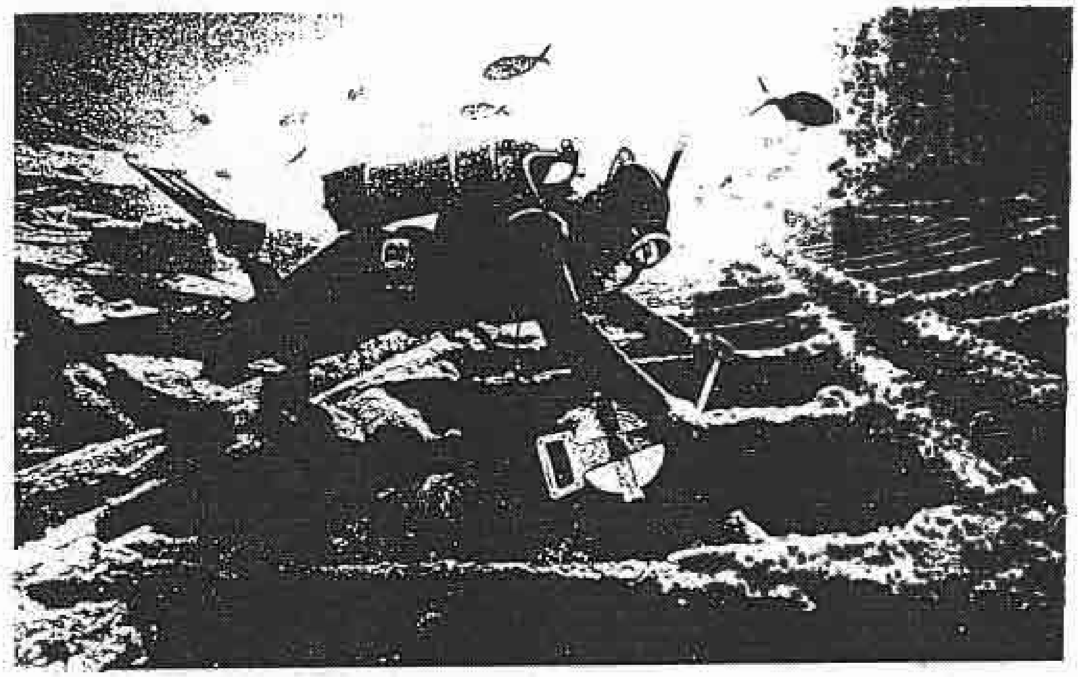
Wreck Trails are becoming more and more popular around the world. Already divers have locally been able to enjoy the Rottnest Wreck Trail and visit the spectacular wrecks around the island such as the *Macedon* and the *Lady Elizabeth*. However, the museum's involvement in these schemes is more deep seated than promoting a sport. Wreck diving comes with serious responsibilities and this is what is kept very much in mind.

The museum is proposing a 'Wreck Divers Passport' and this could be a way for divers to qualify for work with the local maritime archaeology association and ultimately even participate in museum projects.

There are after all even more historic and exciting sites around our coast which are restricted to historical and archaeological studies.

The Maritime Museum in Fremantle has a wealth of experience in the field. In investigating our coastlines shipwrecks, examining them with experts in excavation, conservation and other disciplines, they have been able to display some of the finest wreck artifacts in the world. Starting with the earliest W.A. wrecks of the Dutch East India ships such as *Batavia* and *Zuytdorp*, to the later colonial ones such as those around Fremantle. Their work has made these things available to us all by preserving and displaying our heritage

Museum archaeologist, Mike McCarthy, undertaking a wreck survey.



The scheme they propose is designed to make divers think. Wrecks are an important part of our heritage. They are historical sites that future generations will want to enjoy, just as much as Fremantle's historic buildings like the Round House. Within this scheme divers are encouraged to dive on interesting sites that are comparatively hard to damage. They are at the same time encouraged to consider their importance to us all.

The wrecks should be dived for pleasure but with care for their structures and any artifacts within them. This is what the museum encourages us to do with this new and exciting scheme.

AMONGST THE SHIPWRECKS IN THE FREMANTLE WRECK TRAIL ARE -

ABEMAMA, (1927).
A three-masted wooden schooner of 398 tons, built in Nova Scotia. She caught fire and burned to the water-line within three days of running aground in Jervoise Bay on 26 July, 1927. She can only be seen in properly when winter gales have shifted the sand, and then almost all of her hull is visible.

ALACRITY, (1931).
Originally the *Jean Bart* a 353 ton French built iron steamer of 1893. She was used to tow barges under construction to the Henderson Naval base in Cockburn Sound. In World War I she acted as an unarmed patrol vessel. Having finally been sold for scrap she was blown ashore in a gale near to the *Abemama*. She is now a clearly visible wreck on the beach.

CARLISLE CASTLE, (1899).
Built in Blackwall, London in 1868 to a famous design similar to the large naval frigates of the time. Re-rigged as a barque to reduce the crew, she was wrecked on the northern edge of Coventry reef, 11 July, 1899 whilst carrying railway irons and general cargo. The whole of crew, over twenty, were lost.

D 9 (DREDGE), (1962).
Built in Fremantle during the depression years of the 1930s as the bucket dredge *PARMELIA*. She was sold and renamed as the *D9* after conversion to a suction dredge for work on the Kwinana channels. Now she lies in Cockburn Sound as a comparatively complete wreck, owing to her more recent sinking.

ELIZABETH, (1839)
Three-masted wooden barque of 192 tons that sought shelter from a gale off the Gage Roads, 21 September, 1839. The wind took her however and she lost her sails and spars. Driven through a narrow reef opening off Cottesloe, she beached, and became a total wreck. No lives were lost.

GEMMA, (1893).
A wooden brig of 318 tons, German built in 1868 as the *H. BEENKE*. Bringing coal in 1886 from Fleetwood England, she stayed for use as a hulk. Later in the year she ran aground requiring her to be re-floated and repaired. Her use as a hulk continued until 15 August, 1893, when she was towed to Jervoise Bay and beached.

LONG JETTY, (1921).
This site is not a shipwreck. Nevertheless, it represents a fascinating dive amongst the remains of the jetty that was the first serious attempt at providing good harbour facilities. Its first section was built in 1873 and after years as a popular promenade it was demolished in 1921. The jetsam of many a visiting ship lies amongst the stubs of timber that once were its support.

NORTH MOLE WRECK, (unknown).
Wreck of a barge. Typical of a type once common in the area and used in dredging of the harbour with steam grabs. It should lie under the new harbour extension but owing to its popularity as a novice dive site, the F.P.A. funded its moving with heavy crane barge. An easy and accessible dive.

OMEO, (1900).
Newcastle built in 1853. An iron barque rigged steamer of 789 tons. She carried telegraph poles for the construction of the Darwin to Port Augusta line. Later she became a hulk after being blown ashore at Hamelin Bay. With 500 loads of timber aboard she again blew ashore at Coogee Beach, where her remains still lie rotting in a few meters of water.

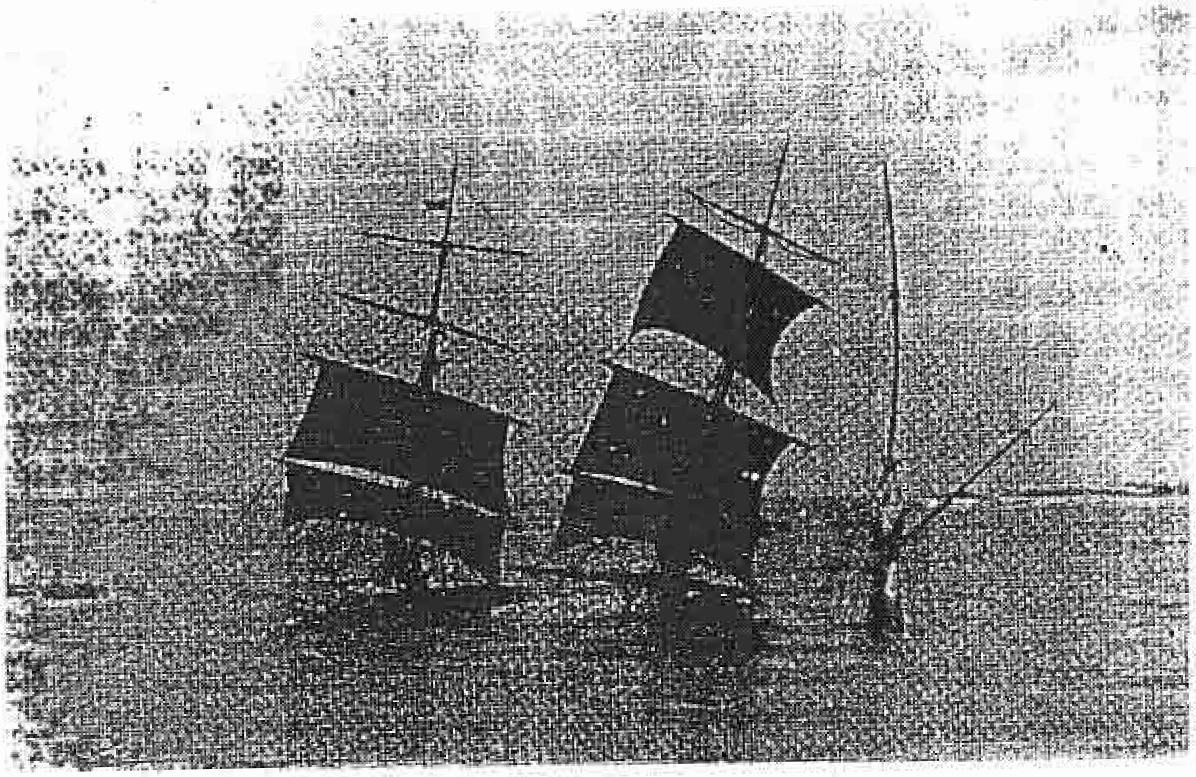
ULIDIA, (1893).
An iron barque of 1,378 ton. Lost whilst bringing rails from Barrow for the Albany to Fremantle line and was one of many similar vessels so engaged. During a severe storm she dropped her anchors in the hope of riding it out. Sadly they dragged and she struck the Stragglers and sank.

APPENDIX FOUR

The North Mole Wreck conservation report.

CONSERVATION PROJECT REPORT

THE SEPIA ANCHOR AND WRECK SITE: CONSERVATION AND SITE MANAGEMENT.



Wreck of the barque Sepia on a reef off Carnac. (Battye Library collection)

SUBMITTED BY ED PUNCHARD

NOVEMBER 1990

AS A REQUIREMENT FOR THE

GRADUATE DIPLOMA IN MARITIME ARCHAEOLOGY

(MA 502)

CONTENTS

self - 6.5   ed - 90/100

SECTION ONE : THE SEPIA ANCHOR.

INTRODUCTION

This section contains the main work from this conservation project. Section two is a discussion and consideration of the related issue of site management.

Between August and October 1990 a series of inspections were made on the Sepia wreck site 1.5 miles S W of Carnac island at Lat. 38°8.22' / Long.115°37.8', in up to 15 metres of water.

During these inspections readings were taken on the Sepia's anchor which was located amongst the wreckage of the bow. A magnesium alloy anode was attached to the anchor and changes in the readings were noted over a period of months. In addition, a number of measurements were taken to asses the environmental conditions that were prevailing in the immediate vicinity.

These readings have been assembled and analysed to provide an understanding of the condition of the anchor, the changes it underwent when protected and the ramifications of this for its conservation. Discussion of wider issues of site management comes from important changes observed during the inspections.

THEORETICAL BACKGROUND

Unprotected iron will corrode rapidly when it is exposed to a marine environment. Submersion will provide the moisture, salinity and oxygen that will guarantee the denigration of the metal. Great lengths are taken by engineers who must install iron and steel in marine conditions to protect their structures or hulls from corrosion damage.

There is however another phenomenon that quickly occurs that also has a significant effect on the corrosion process. Unlike the oxides of metals such as copper or its alloys, or lead and alloys containing lead, ferrous oxides do not inhibit marine growth formation, whether soft or calcarous. A feature of an iron shipwreck site is the considerable calcarous formations that colonise any exposed iron.

The rate of colonisation is dependent on the water depth, temperature and other factors such as the local pollution levels. The marine growth provides a physically protective layer from the abrasion of sand and sediment in the sea-water. When marine growth spreads a number of previously separate items can be conglomerated within a group. This can build up and calcarious elements of the growth start to form a concretion layer. Within a short number of years this concretion can have significantly changed the corrosion environment on the surface of the iron. The interaction between the corrosion products and the material next to the iron will ultimately create an encapsulating barrier of considerable thickness. This covering has the ability to greatly inhibit the oxygen that is able to reach the iron and slow the rate of corrosion.

The barrier that is built radically changes the chemistry of the iron's surface. Cl^- ions migrate into the concretion and H^+ ions flow outwards both forming high concentrations. Iron II chloride is the main corrosion product and this reduces the average pH. value to the region of 4.8 or so. This is well below the usual pH. for sea-water at approximately 8.2.

The other factors at play which effect the corrosion levels on the iron the are dissolved oxygen levels and salinity within the surrounding sea-water.

'Measurements of dissolved oxygen on wreck sites around the Australian coastline show little difference between surface levels and those found at depths of up to 30 metres'. (MacLeod 1989). Depth has an effect and water movement is significant one where aeration is caused by surf and wave action.

Salinity is the most constant factor governing corrosion rates in sea-water. Generally in the region of 35‰S. with few changes to its proportional content. However some variations do occur. Coastal regions can see considerable shifts due to fresh water run offs from rivers and so on.

Salinity can effect the corrosion levels of iron in a number of ways. The sea-water is the conductive medium which allows the ionic passage between anodic and cathodic areas and its effectiveness in this way will vary according to the salinity levels. Salinity can also form protective layers on some materials and destroy those on others effecting dissolved oxygen levels (MacLeod, I.D. & North, N.A.,1987).

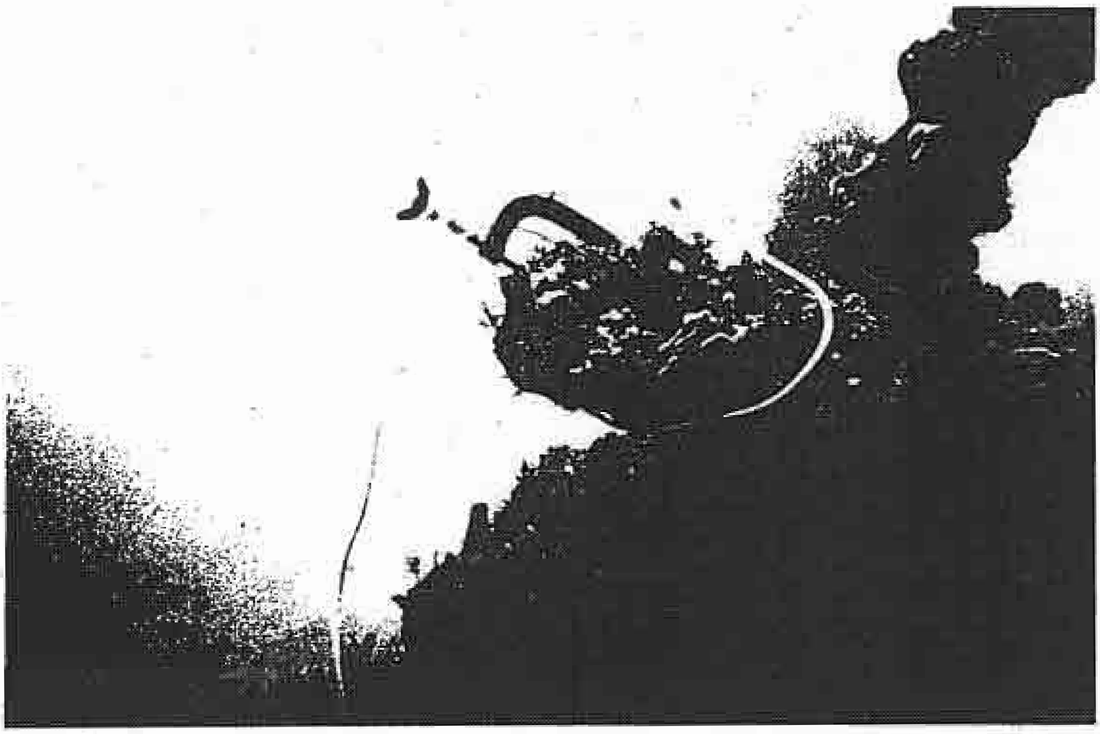
These then are the theoretical criteria that underlie the examination of the Sepia anchor. It is with these in mind that certain types of readings were taken to examine the condition of the Sepia anchor fits into this theoretical picture.

EXAMINATION OF THE SEPIA ANCHOR AND WRECK SITE.

The first dive on the Sepia site was on 22 August 1990. The anchor was located at the bow and the overall condition of the wreck was visually assessed. The presence of artifacts was noted as was level of burial and scour conditions amongst the wreckage. Four positions on the Sepia bow anchor were designated and holes drilled to allow pH. and corrosion potential readings to take place. An anode was attached to the anchor by means of a 'G' clamp and good quality electrical cable.

The purpose of this work was to provide changing data valid over a period of weeks that would allow us to establish the corrosion activity of the anchor.

Figure one. *Photograph of 'G' clamp providing electrical contact between anode cable and anchor.*



On three subsequent occasions; 5 September, 19 October and 26 October, the anchor was returned to and re-measured for pH. and corrosion potential

Corrosion potential readings were taken using a silver/silver chloride half cell reference electrode coupled to a digital multi meter housed appropriately in a water-tight aluminium case. A hole was drilled into the concretion using a suitable gauge masonry bit, within a pneumatic drill attached to a scuba bottle and reducer capable of delivering air at the correct pressure above ambient. To establish the correct pH. reading this is taken first by inserting the pH. probe into the hole and recording the result. A platinum coated electrode attached to the multi-meter is then pushed into the same hole and pressed against the parent material to ensure a good electrical contact. The unit is allowed to stabilise before any corrosion potential reading is taken.

Observations were also made of the anode weight and condition and on some occasions readings were made to establish local environmental conditions. The results of all these inspections are listed below in tabulated form with corrections to the corrosion potential levels to adjust them to the Standard Hydrogen Electrode scale.

Table one: Readings taken, E_{corr}. followed by pH. (where taken).

LOCATION	22/8/90	5/9/90 WITH ANODE	5/9/90 NO ANODE	5/9/90 RE-ATTACHED	19/10/90	26/10/90
BETWEEN CROWN AND SHANK	-83.5/6.87(A)	-191.5/7.41(C)		-172.5	-124.5	-81.5
ANODE ATTACHMENT	-84.5	-191.5	-114.5	-172.5	-104.0	-74.5
ADJACENT PLATE	-78.5/7.27(B)	-109.5/6.81(D)				-74.5
BOW PLATE	-72.5	-36.5			-37.5	-62.5
CROWN AND SHANK			-112.5/7.41(E)	-180.5		-74.5

During the inspections a number of environmental readings were taken and interpreted as shown in table three. Also the oxygen content of the water was measured at different depths. Using the relative water temperature as given in table two, the %age saturation level was then graphically obtained as per Rawson, D.S. 1944. and demonstrated in Graph one.

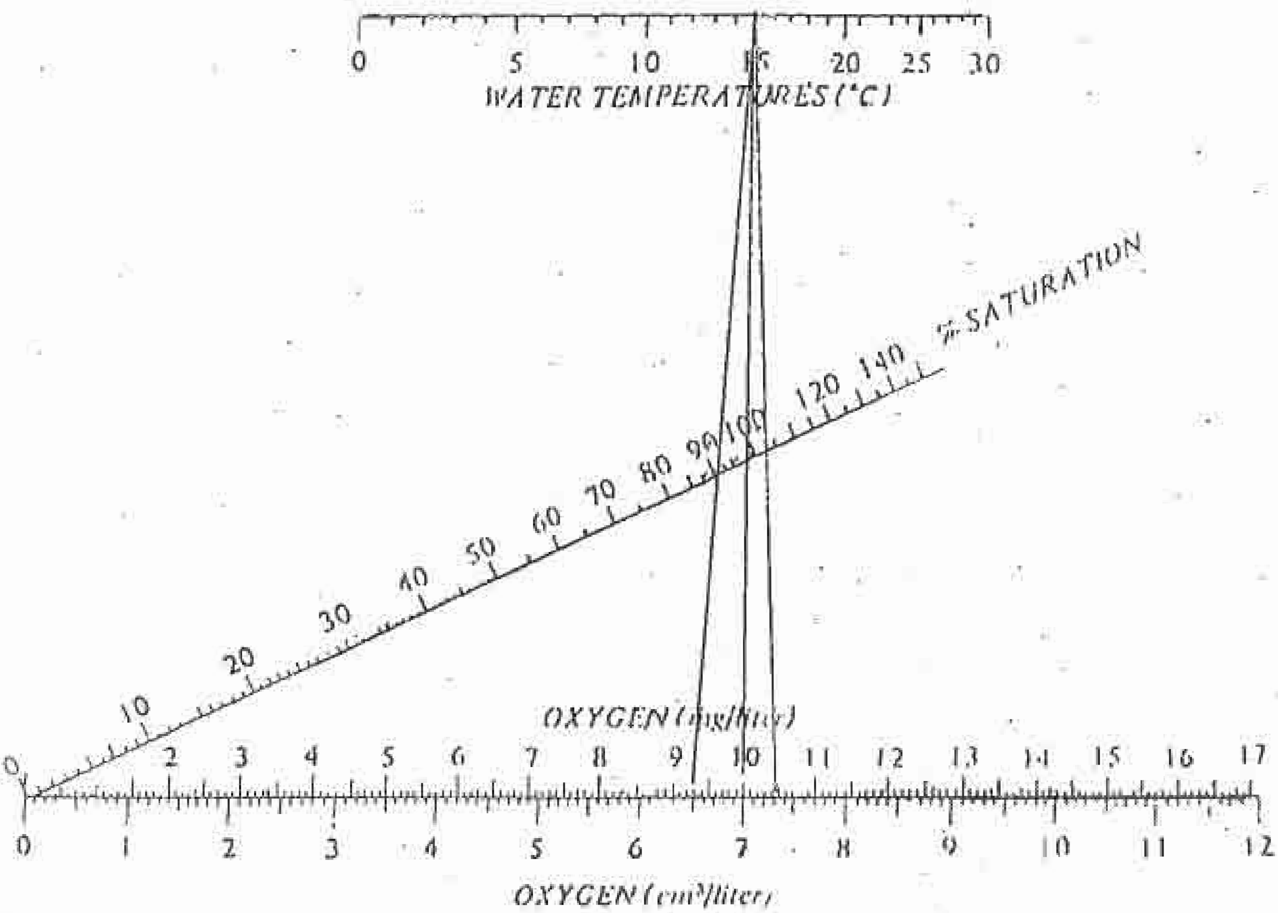
Table two: *Measurements of water temperature and pH.*

DATE	TEMPERATURE C°	pH. WATER	DEPTH
22/8/90	14	8.1	13M
5/9/90	15	8.1	12M
19/10/90	15	8.1	13M

Table three: and *Measurement of oxygen levels, salinity and calculated oxygen saturation %age conductivity.*

DEPTH m.	OXYGEN ppm.	% SATURATION	CONDUCTIVITY at 25°C mS	SALINITY(ppt)
13	6.5	91	55.8	38.0
9	7.0	98	54.9	37.4
5.	7.3	103	54.9	37.4
1	7.3	103	54.7	37.2

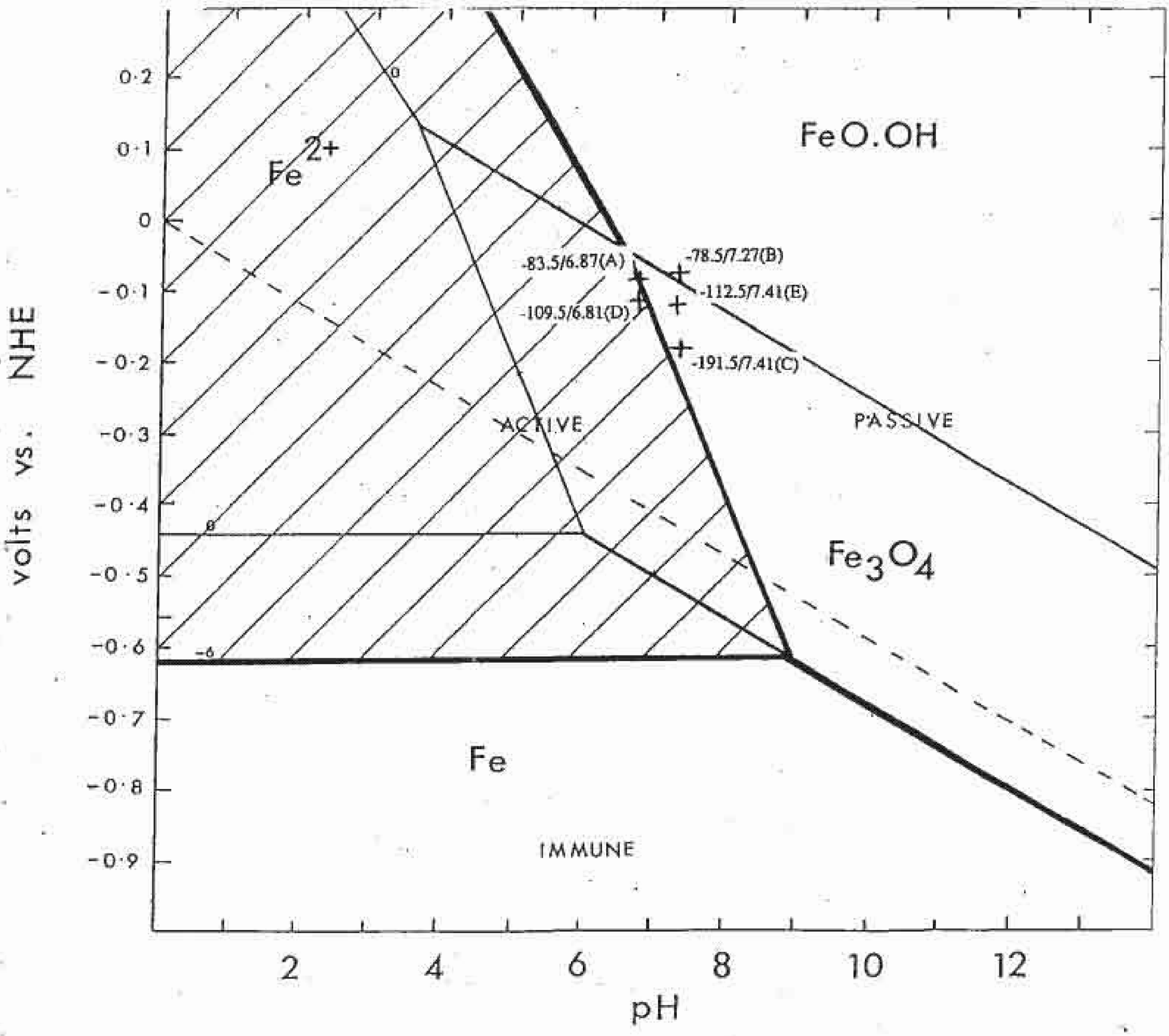
Graph one: Calculation of oxygen saturation levels Dawson, D.S 1944.



E_{corr} and pH. data contained in the above tables have been assembled and placed onto a Pourbaix diagram for iron and water at 25°C with soluble species at 10^{-6}M concentration. The data has been converted appropriately to Standard Hydrogen Electrode scale .(Ag/AgCl sea water reference electrode +0.293 volts vs SHE). It is unfortunate that problems occured with the operation of the pH. meter throughout the period. Electrode contamination and ingress of sea-water into the drill holes have left the pH. data less complete than would have been normally desired.

Notwithstanding this the data has been graphically represented to allow interpretation and is shown below in Graph two.

Graph Two: Pourbaix diagram showing plots of readings obtained from the Sepia anchor.



INTERPRETATION OF RESULTS

Examination of the plotted positions on the pourbaix diagram and data contained in the earlier tables lead us to a number of conclusions. First of all it is clear that the first corrosion potential results taken on the 22 August, are low indicating corrosion underway at a reasonable rate. On there own they are only part of the story and the pH. results must also be examined. They lie at 6.87 and 7.27 and frankly seem rather too alkaline. They do place the plots into the active zone on the Pourbaix diagram but not to far from the passive zone.

When we then consider the measurements taken on 5 September, whilst the E_{corr}. has as one might expect have dropped, the pH. readings at 7.41 and 6.81 are remarkably similar to those of the previous inspection. Given the clear effect that the application of the anode has had in reducing the corrosion potential and the inevitable chemical changes to the micro environment that must follow on from this, one must question the validity of some of the pH. readings.

It seems likely then that on the earlier occasion some fault existed in the meter or there was a significant ingress of water into the area immediately adjacent to the material underneath the concretion. it's not easy to get it right!

Having noted this inadequacy with the data, it is equally obvious that the application and removal of the anode and its final reduction to nearly nothing are very well reflected in the E_{corr}. data This points to the likelihood that the anode was protecting the anchor for the duration of its attachment and that the expected changes to corrosion rates and modification of the micro environment occured.

There are though some further areas that should be mentioned as a result of the observations made of the anchor protection. In particular the rate of reduction in the anodes size was rapid indeed and this should be examined to establish why this should be so and how it may have influenced the experiment.

Having drawn the conclusion that the anode was protecting the anchor the plots on the pourbaix diagram (whilst inadequate due to the poor pH. readings), might suggest that the movement towards the passive zone might perhaps have been more substantial, especially given the rate of the anodes dissolution. Why should this be so and how can we extract an explanation?

The first and really rather obvious clue lies in table one. The corrosion potential readings were not restricted to the examination of the anchor but made to include adjacent ironwork such as the bow plate alongside the anchor and another adjacent section of iron. The subsequent corrosion potential readings that were taken after the attachment of the anode to the anchor show that one of these adjacent iron items is in electrical contact and that the other is not.

The degree to which this might have effected our experiment is not clear but we can try to establish this by quantifying the current flow. How that current flow compares to what might be expected for an anchor of this size would allow us some idea of to what degree the contacting iron work is 'loading' the system.

CALCULATION OF CURRENT DENSITY

The anode that was deployed was a standard aluminium/magnesium alloy. Owing to the absence of the original weight (≈ 3 kg) we are basing the calculation on the basis of its weight as if it were all aluminium.

Thus we are considering the oxidisation of the Aluminium in the reaction:

$$Al \longrightarrow Al^{3+} + 3e$$

The anode is believed to have lost an original weight of approximately 3 Kg of aluminium, with aluminium at an atomic weight of 26.9815.

Time for the calculation is 44 x 24 x 3600 giving 3801600 seconds.

A Faraday
Electron standard is 96487, therefore to establish the current:

$$\frac{3{,}000}{26.9815} \times \frac{3}{1} \text{ (Moles of electrons)} =$$

$$\frac{9{,}000}{26.9815} \times \frac{96487}{3801600} \text{ (Electron standard) = (Time)}$$

8.5 Amps (Current)

To convert this to Current density:

The surface area of the anchor has been established as being $4.45m^2$.

Therefore current density =

$$\frac{8.5}{4.45} \ Am^{-2} =$$

$1.91 \ Am^{-2}$

$1.91 \ \mu Acm^{-2}$ 191 $\mu A \cdot cm^{-2}$.

This is a high current density for the given size of anode and surface area of the anchor. This confirms therefore that the anchor is likely to be in electrical contact with other iron items on the shipwreck, as already suspected from the corrosion potential changes on the adjacent material.

The possibility is then that the 'loading' of the system in this way reduced the movement towards the passive zone that we witnessed in the examination of data within the pourbaix diagram.

CONCLUSION

The data and analysis above indicates a number of hypotheses are true or possibly true. They are;

> That the anode protected the anchor, reducing corrosion potential and increasing pH.
> That there was most likely an alkaline shift in the micro environment.
> That the anchor was in electrical contact with other iron material.
> That this contact reduced the effectiveness of the protection for the anchor.

The expected corrosion rate for pre-disturbance is 0.11 mm/year (MacLeod, I.D. & North, N.A.,1987).

This would have been markedly reduced with the effects of cathodic protection conservation, as has been the case on the Sirius and other sites like the Xantho engine at 0.008 mm/year (MacLeod, I.D., 1985).

RAMIFICATIONS FOR SITE MANAGEMENT

The protection of iron and steel shipwreck material is an important one due to the wide variety of such material that is of historic significance and requires conservation protection.

In addition, earlier studies concerning the effectiveness and consequences of in-situ cathodic protection, show that the changes that occur to the micro-environment are indeed the changes that start the conservation process. The chloride ions defuse back out through the concretion and the surface acidity is greatly reduced.

When we consider that in the laboratory immersion in NaOH is a primary conservation treatment, the alkaline shift in the micro-environment that results from cathodic protection is a way of bringing this process forward to a much earlier stage.

The work that was undertaken on the Sirius anchor, its cathodic protection utilising aluminium engine blocks, may have been an act of first aid but its results were more far reaching. The concretion had been partially broken during moving and within two hours the exposed part of the shank was covered in a red-brown iron (III) oxy-hydroxide film. (MacLeod,1988) C.P. measurements confirmed this and the anodes were installed to prevent the damage of the considerably increased corrosion level.

The cathodic protection of the Sirius anchor over a fairly long period allowed both re-covering by new calcarious concretion and (as was later discovered) the conservation of considerable detail on the iron surface with little of the expected spalling. When removed the concretion itself was also seen to have greatly hardened as a result of the chemical changes.

Given these earlier results further work on the Sepia anchor would provide an interesting comparison and repeatablity test. The issue of electrical isolation may have to be resolved by some material movement but the treatment itself should be able to mitigate against the likely concretion disturbance that would result.

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PART TWO : THE SEPIA WRECK SITE, CONSERVATION AND MANAGEMENT.

The successive dives on the Sepia site and observations made during these visits pointed to a number of areas that also deserve consideration. This report concentrates on the Sepia anchor but the general condition of the site may warrant action to protect it.

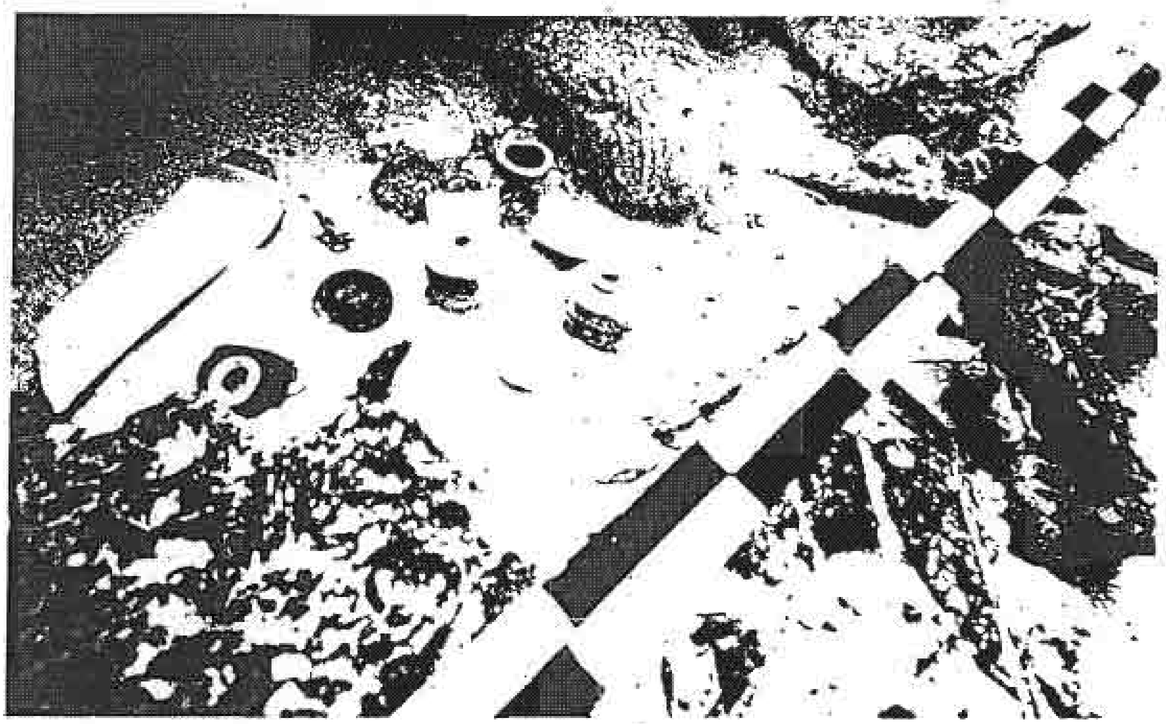
In addition to corrosion discussed in section one, factors such as scour, the associated effects of mechanical damage and changes to micro environment due to burial and exposure, changes in marine growth cover and interference from divers, are all pertinent issues.

The value of the Sepia site is unlikely to warrant such protection as application of imitation sea grass as with the William Salthouse by the Victoria authorities. However we should note the significant levels of sedimentary movement that occur due to the prevailing scour conditions on the site. In particular the re-exposure of the cargo areas in their remarkably sound preserved order. The chemical changes due to the exposure and re-burial could make for interesting further pH. and bacteriological studies.

The additional problem of souvenir hunters is a worry and during the course of our study interference and removal of artifacts was evident. The 'G' clamp that attached the anode to the anchor was stolen and mooring ropes and a divers knife were found on the wreck, clearly showing that divers had been there between our inspections. The theft of the 'G' clamp shows that divers can disregard the activities of others.

Below in figure two, the photograph shows a number of artifacts that were observed during an early dive. They include the bowl of a clay pipe, complete ink pots and a variety of shards. On a subsequent dive these were all missing, presumed removed by sport divers.

Figure [illegible] *Artifacts found and later lost from the site including clay pipe bowl and complete ink pots*



The loss of these items emphasises the sad reality that attractive movable items are often lost to pilferage. How these problems can be addressed is the subject of some considerable debate and one possible solution is to encourage responsible wreck diving on archaeological 'safe' sites. This can remove or reduce the burden from the more vulnerable sites, whilst you are educating divers to be responsible.

This issue is discussed further in the following section where a proposal divert sports divers attentions whilst educating them is outlined.

APPENDIX I

A SUGGESTED MANAGEMENT PROGRAM:

THE NORTH MOLE WRECK.

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.

However 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 . 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.

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 oil-field 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.

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).

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 Appendix II.

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.

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.

2.3.1. Methodology

A cathodic protection system would 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. / pH. 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. This is essential when semi trained, volunteer personal are utilised to undertake inspection work.

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.

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.

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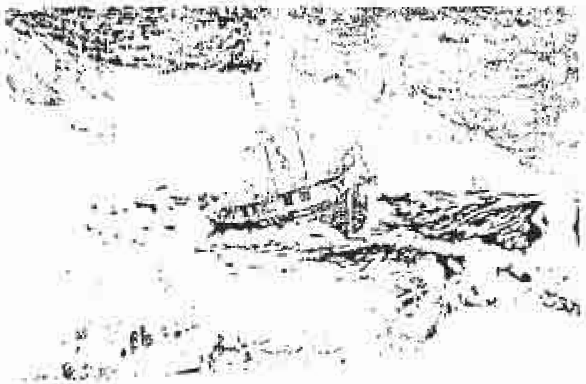
APPENDIX II

WRECK DIVERS PASSPORT.

PRO-FORMA DATA SHEETS.

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

Shipwreck	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 Glasgow 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.		

CORROSION POTENTIAL MEASUREMENT SHEET

NORTH MOLE WRECK SITE

DATE:

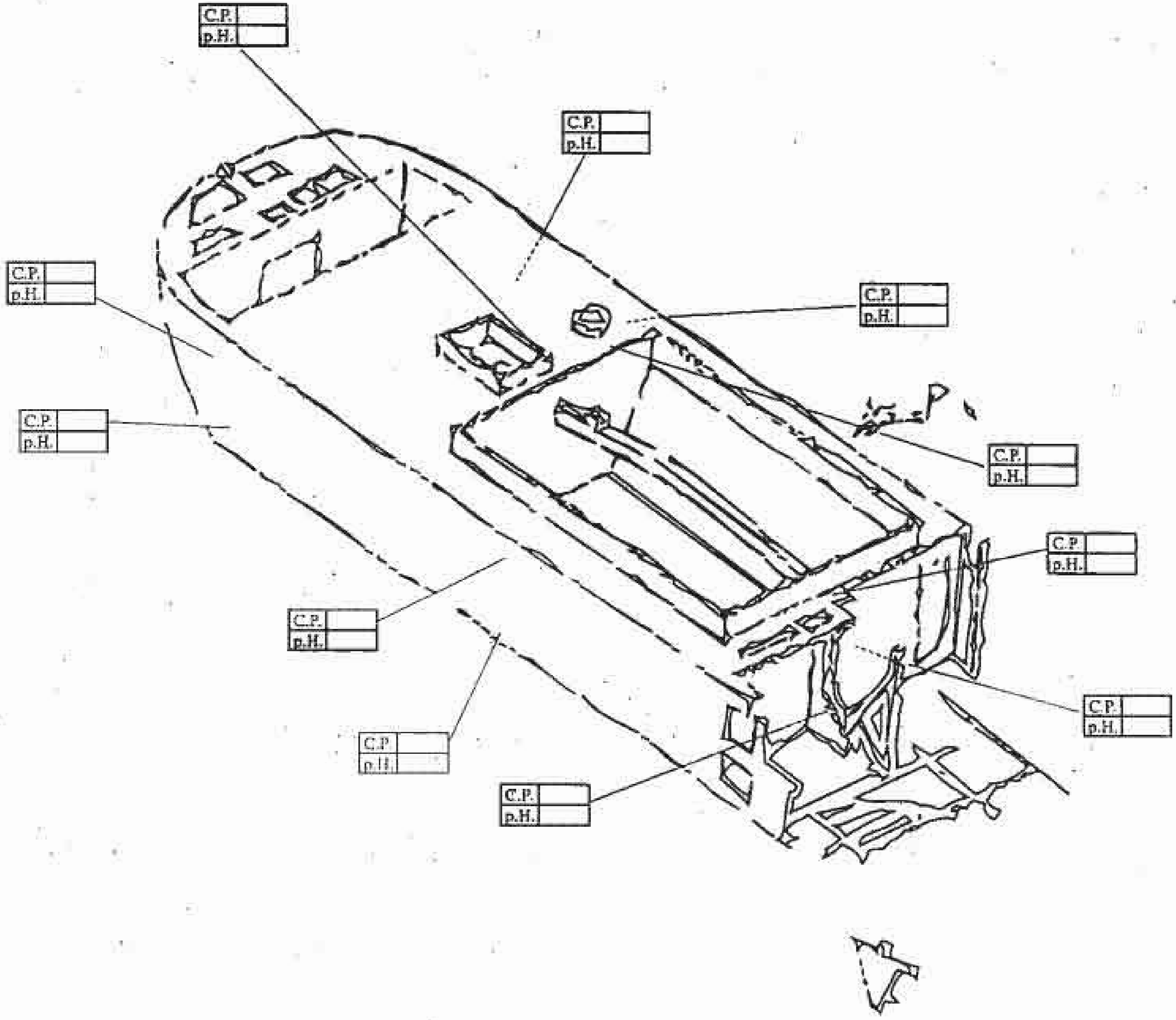
DIVER:

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

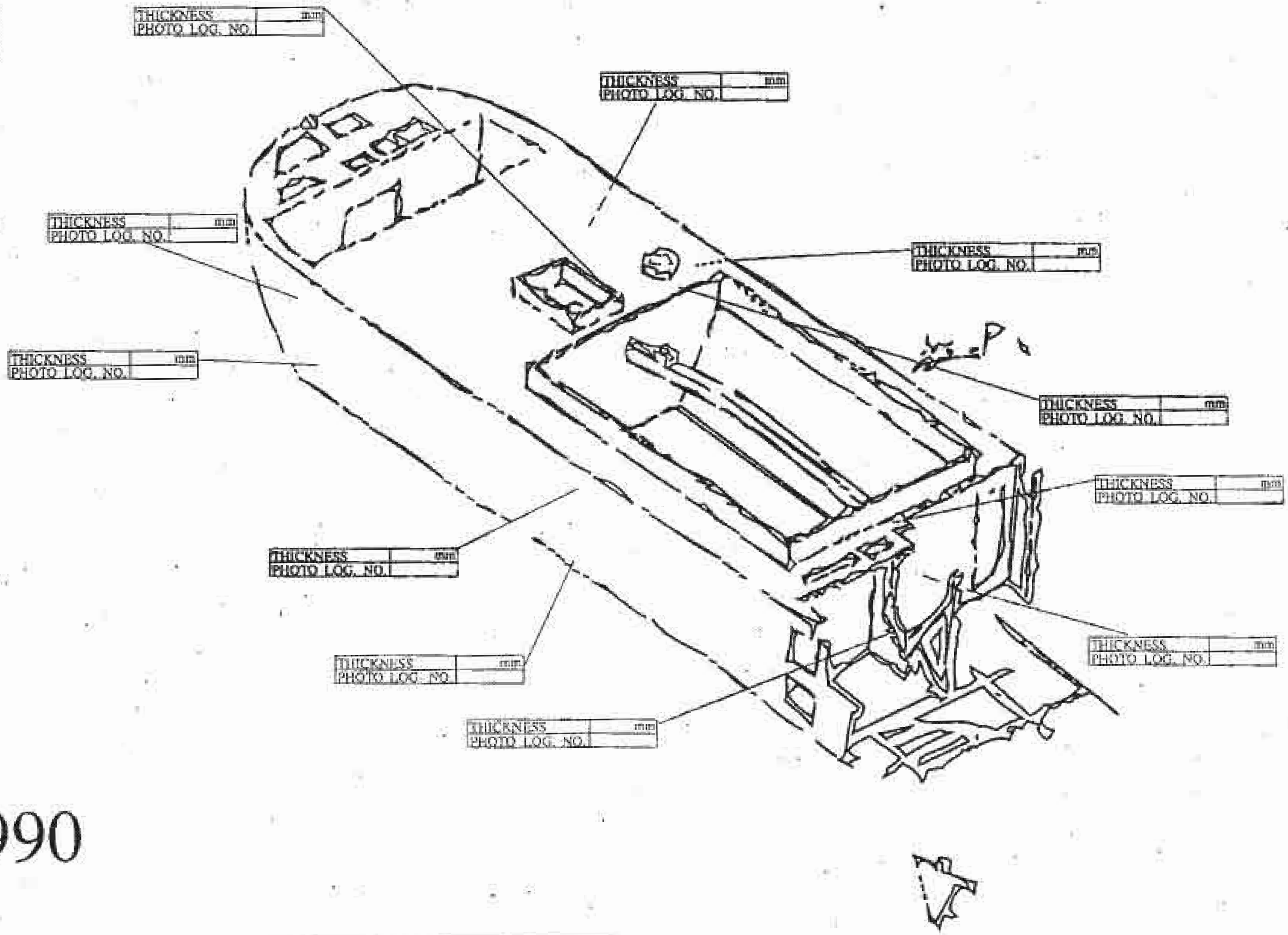
MARINE GROWTH SURVEY

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.

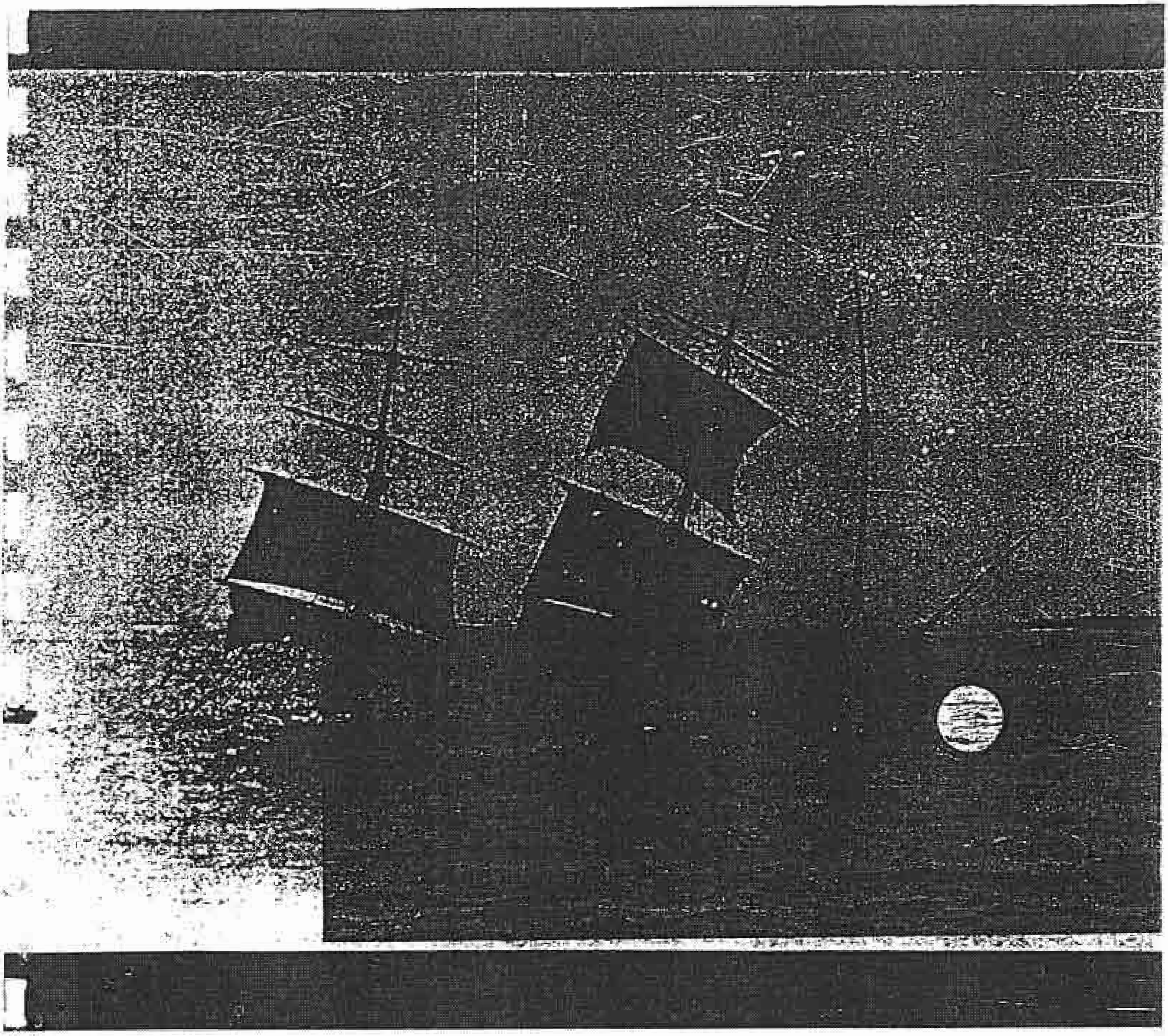


Western Australian Maritime museum

1990

APPENDIX III

WRECK IDENTIFICATION.



Overlay of original [illegible] The modern photograph [illegible] The overlay demonstrates the [illegible] reference to the island configuration [illegible] the North East