REPORT FOR THE SRI LANKA DEPARTMENT OF ARCHAEOLOGY

# GALLE HARBOUR PROJECT 1996–1997

SRI LANKA

AUSTRALIA

NETHERLANDS

ARCHAEOLOGY

HISTORY

CONSERVATION

TRAINING

AUSTRALIAN NATIONAL CENTRE OF EXCELLENCE FOR MARITIME ARCHAEOLOGY SPECIAL PUBLICATION NO. 4

SRI LANKA DEPARTMENT OF ARCHAEOLOGY REPORT ON THE JOINT
SRI LANKA–AUSTRALIA–NETHERLANDS
GALLE HARBOUR PROJECT 1996–1997


# SRI LANKA DEPARTMENT OF ARCHAEOLOGY REPORT ON THE JOINT SRI LANKA–AUSTRALIA–NETHERLANDS GALLE HARBOUR PROJECT 1996–1997

## ARCHAEOLOGY, HISTORY, CONSERVATION AND TRAINING

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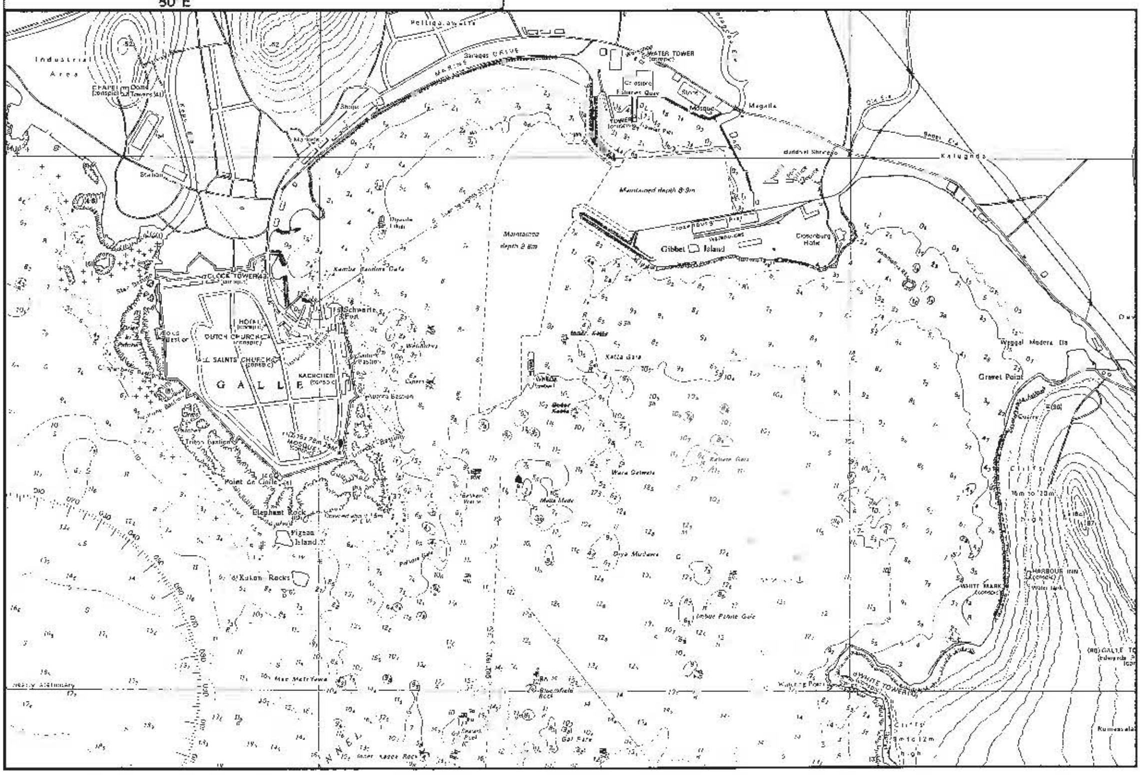

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# FOREWORD: A CHANGE OF COURSE: THE SIGNIFICANCE OF 1996–97

**Background**

It is not my intention to deal with the origins and development of this Project—later upgraded to a Programme—as these aspects have been dealt with in depth in earlier reports and publications. My intention here is to deal with certain aspects of the 1996–97 seasons: to explain how and why they were quite different from the earlier ones, and how they influenced changes that occurred in Sri Lanka concerning maritime archaeology in general and to the Galle Project in particular.

Yet all these can best be understood against the backdrop of the earlier seasons and it is necessary to re-state the motives that led to the adoption of this Project as an on-going programme. These were:

1. Training young archaeologists in maritime archaeology, as a first step towards establishing a unit for this subject in the Department.
2. Building up of a database of shipwrecks in Galle Bay, known to be a historic port, because the construction of a modern cargo-handling facility here was being seriously considered.
3. Using the experience gained, and work done, as the basis for formulating a maritime archaeological policy and a formal legislative framework.

At the time the Project was first undertaken, maritime archaeology was neither taught in the Universities nor practised by the Department of Archaeology in this country. Hence, no specific funding had been voted in the annual budgets in any of these institutions. The 1992–94 seasons were therefore conducted on a non-formal basis, with limited funds contributed by several institutions from sources available to them. The main institutions were: The Archaeological Department (under its Exploration programme), the Central Cultural Fund, the Department of Maritime Archaeology of the Western Australian Maritime Museum and the Post Graduate Institute of Archaeology. Non-financial assistance was also afforded by the Department of National Museums and the Sri Lanka Navy, and by volunteers from the Maritime Heritage Trust of Sri Lanka and the Sri Lanka Sub Aqua Club who provided the volunteer divers and Project Co-ordinators.

This non-formal grouping of resources had several shortcomings, chiefly the lack of resources to carry on an optimistic programme, in spite of the best of intentions. In the 1996–97, this situation changed very significantly, enabling the work to be taken in hand more systematically. This Foreword, therefore, will deal with the changes that took place, the causes therefore and their consequences.

**Galle Harbour Development Plans**

In the years 1994–95, at a time when the present Project was languishing, the newly elected government of Sri Lanka actively resuscitated the plans to build a major container terminal and trans-shipment port in Galle Bay. Several plans and options were considered and a final plan adopted. The government's clearly stated intentions were to construct a port which could accommodate the overflow cargo from Colombo and to afford employment and investment opportunities in the Southern Province. Steps were taken to award a tender on a 'Build, Operate and Transfer' (BOT) basis, to a selected developer. The plan was ambitious and costly, but had far-reaching consequences in terms of development.

However, concern was raised by several institutions and individuals over its impact on the ecology and environment of Galle Bay. The concern had much to do with the large area of the sea bed that was to be excavated, as well as the area that would have to be reclaimed to build a large concrete apron and all the appurtenances of a modern port. These two areas, which are contiguous, were located in the eastern part of the port, along the Roomassala coastline, which forms the eastern side of the bay. Together, they would cover approximately one-third of the surface area of the bay. The plan also included the construction of a breakwater providing a single navigable entrance which would serve both the new facility to the east of the bay, as well as the existing fisheries–break-bulk harbour sited in the middle of the bay on its northern shore.

Environmental concerns

Several organisations, including NGOs, institutions and concerned individuals voiced their disapproval of the plan because of their special interests. Among them, were those concerned with the protection of a very distinctive type of coral reef that would be destroyed, along with a large number of types of fish and other forms of marine life that were endemic and unique to the site. Others were concerned with the consequences to the natural environment of Roomassala ridge, which is home to several unique types of fauna and flora. Yet others were concerned with the impact on the small fishing communities who operated from the site. Each of these groups sought to influence the government to change its plans. These concerns were to be looked into by the government, as it was part of the requirement for the developer to commission an Environmental Impact Assessment (EIA). The Central Environmental Authority would in turn subsequently scrutinise this report. At the time of writing, the plan has yet not been put into effect due to the developer's failure to meet deadlines, however, the government has not, as yet, abandoned the plan.

Impact on the cultural environment

From an archaeological point of view, the proposals affected two institutions, and each took meaningful steps to investigate and take appropriate action. One was the Galle Heritage Foundation which is responsible for the preservation of the Dutch Fort of Galle, a UNESCO World Heritage site. Their main concern was the effect of the major blasting work that was needed to create the deep basin on the sea floor. The same rock stratum found there extends into, and forms part of the bedrock of the Fort. The question was whether the seismic effects of the blasting would endanger the Fort. Independent and experienced engineers, who had considerable experience with similar situations in building this country's Mahaweli Power and Irrigation system, expressed the view that blasting technology was available that would, if used, cause no harm to the Fort or the city of Galle. The matter rests there but the Archaeological Department (the Fort is an archaeological monument) has the powers to monitor and control all blasting activity in the vicinity of archaeological monuments.

The Archaeological Department was equally concerned with the impact of the plan on the maritime archaeological activity in the Galle Bay. Unfortunately, this Project was not (as stated above) one formally approved as a departmental project. It was, as a rescue project only, that the assistance of the Ministry of Cultural Affairs could be sought. As a government body, the Department can only seek to influence, modify and mitigate the effects of any activity adopted as policy by the government. To seek its abandonment requires a very strong case. Yet much can be achieved within these limited means.

The media, naturally, took an interest in the matter, as it was controversial and took a concerned and not antagonistic attitude. For instance, the *Sunday Observer* 31 December 1995 carried a feature headlined 'Galle modernisation will endanger sunken treasure' in which the point was made 'that appropriate exploration and emergency salvage excavations be undertaken to retrieve potentially priceless archaeological treasures which could otherwise be threatened by dredging operations.' Similarly, the *Midweek Mirror* of Wednesday, 29 May 1996 devoted a middle-page spread on the subject, combining the ecological and archaeological problems. It carried the headline 'Build Galle but watch the balance'. What makes these instances worthy of comment is that they urged the protection of the endangered material, while not seeking to stop a development project many people were looking forward to. In countries like Sri Lanka and, indeed, even in more industrially developed countries, essential development cannot be overlooked. The more harmful effects of such development can, however, be minimised. Archaeological interests must find a way of being served, within these parameters

The Galle Project of 1996–97 was one of the first instances where this was successfully done in Sri Lanka.

Positive governmental action

Against this background, the visit to Galle by the Minister of Cultural Affairs, Hon. Lakshman Jayakoddy, was of critical significance. With his considerable knowledge of heritage matters, he realised that the harbour development project would have an adverse effect on a site which had been considered as a port for over two thousand years. On his return to Colombo, he called for all published reports on the previous seasons' work. He concluded that:

(a) A rescue operation had to be mounted;
(b) This could not be done slowly and on an informally funded basis;
(c) Expertise from abroad had to be obtained; and
(d) The matter must be sanctioned at Cabinet level and inter-ministerial linkages set in place.

The last is significant, as the Ministries concerned with the harbour development project had to be assured that there was no hidden agenda to sabotage that project. The assurance was given that the exploration and rescue work would be carried on in the affected areas only till the actual construction work commenced. This was expected to take place at the end of the immediately following six-month period, and a time-window of six months was permitted. The Minister then asked the Department for an estimate of expenditure, but it was not possible to make such an estimate, given the Departments lack of experience in maritime archaeology. The Western Australian Maritime Museum was asked to help in this matter and they responded quickly. But even before the estimates were finalised, Cabinet approval was granted for a sum of Rs.15 000 000 to be allocated for the project. The matter was then given over to the Department to be translated into action.

**The 1996–97 season**

The above narration explains the differences between the pre- and post-1996 seasons of work. The Galle Project now ceased to be non-formal in nature and became a major commitment of the Archaeological Department. Funds were made available through the Department and the Department was accountable, not only for the proper conduct of the rescue operation, but also for proper accounting of funds. The change of status from non-formal to formal meant that the entire responsibility lay with the Department and the question of the position of the earlier co-participants in the project arose. This was solved satisfactorily. The Central Cultural Fund only provided conservation personnel and facilities. The Post Graduate Institute of Archaeology made available its previously partially trained maritime archaeology trainees who were given PADI training as a refresher course and became a very useful part of the team. The volunteers from the Maritime Heritage Trust of Sri Lanka and the Sri Lanka Sub Aqua Club continued to co-ordinate the project as before, but with one important difference. For the duration of the rescue project their efforts were paid for as consultants, whereas, previously, they had worked on a purely unpaid basis. Registration of artefacts was continued to be done by the University of Peradeniya and two persons with specialist knowledge and experience joined the group: a consultant conservator (Ms Nerina de Silva) and a sedimentary geologist (Dr Ananda Gunatilaka). The Department of National Museums became more closely linked with the project and released premises for the construction of a conservation laboratory, as the post-conservation exhibits were to be placed on display in the Maritime Museum. The Museums Department had also recruited one of the maritime archaeological trainees to its normal cadre and he, too, participated in the rescue operation. The Sri Lanka Navy also continued its logistical support and permitted the use of base in the harbour as an operational base for the maritime archaeology.

**The Plan**

As mentioned above, 1994–95 was a lean period for the earlier, non-formal project, as funds available both in Sri Lanka and Australia were insufficient to carry out a meaningful season of work. Co-ordinators Jeremy Green and Somasiri Devendra, however tried to keep it from fading away and by October 1995 had agreed upon a modest plan of work for January–February 1996. This was about the time that the Minister's work also received Cabinet approval. In November, I asked Devendra to consult with Green and any others and prepare a project proposal and estimate. I required the proposal to be structured as follows:

1. Stage I: exploration (side-scan sonar etc.)
2. Stage II: limited sampling from a wide range of wrecks and sites

Identified in stage I.

3. Stage III: intensive salvage of priority wrecks and sites identified

In stage II.

4. First aid conservation and long-term conservation of finds.
5. Processing of finds: completion of site archive, analysis and interpretation.
6. Completion of final report.
7. Publication of final report.
8. Long-term storage of finds.

The response I received was so quick that I had problems in meeting the requirements. One major factor that had been underestimated was the need for a conservation laboratory on site before any retrieval could be undertaken. On the other side, the planning done by the two Co-ordinators in October, enabled a small team to come from Australia by mid-February: in fact the team was at work a day or two before the Cabinet approval was formally given. The final structure of the project was amended as follows:

**Phase I**

| | |
|---|---|
| Stage 1. | Side Scan survey (2 weeks) |
| Stage 2. | Preliminary investigation, pre-disturbance survey and Sampling (4 weeks) |
| Stage 3. | Rescue and retrieval (approx. 6 months) |

**Phase II**

| | |
|---|---|
| Stages 4&5. | Processing and conservation (ongoing operation) |

Stages 6&7. Completion and publication of Reports (at end of Stages 2 and 3)

**Phase III**

Stage 8. Re-modelling of Galle Maritime Museum (long-term)

It need hardly be said that even this underwent amendment as work progressed. As this is only an foreword to the Report proper, the plan in action will not be dealt with here.

**Long-term effects of the 1996–97 season**

The significant and somewhat dramatic finds of this season made a favourable impression on those involved in formulating a national policy, and a legislative framework concerning the underwater cultural heritage. The Department had been engaged in moving several significant amendments to the Antiquities Ordinance. Among them was the specific power control all archaeological work in the territorial waters of the island. In May 1998, these amendments were passed, without division, by Parliament. All maritime archaeological work 'within the territorial sea of Sri Lanka' (defined as 'the area declared to be the territorial waters of Sri Lanka by Proclamation under the *Maritime Zones Law*, No. 22 of 1976') have now been placed under the control and supervision of the Department. Provision has also been made for penal action against transgressors, (such as pirates of underwater artefacts). A further piece of legislation, providing for a Maritime Cultural Heritage Authority (also under the Director General of Archaeology) is in the last stages of completion.

The Amendments referred to above have introduced several benchmark criteria which have a significance in terms of maritime archaeology. They provide for the financing of urgent archaeological projects, such as the Galle Project. To permit development to take place and to protect the heritage without placing an additional financial burden on the government, the Amendments provide for environmental impact assessment surveys of any sites that are being considered for development work (either by the Government or other) by the Department. The cost of such surveys and of the work involved in preservation, conservation, recording, etc. will be borne by the developer who shall set apart *one per cent* of the total cost of the development work for this purpose. There would, therefore, be no more need to solve problems like those that beset the Galle Project in 1994–95.

The Assessments referred to above would have to be completed within a required time frame. Since the material and personnel available within the Department may be strained by this requirement, provision has also been made for the delegation of the Director General's powers to 'any person possessed of special expertise and resources in, or for the exploration, excavation, conservation and restoration or maintenance...' Under this proviso, it would be possible to call upon the special expertise and resources from outside the country, should it be necessary. This has a significance in relation to areas of expertise not fully developed in Sri Lanka, such as maritime archaeology.

Finally, at the time of writing this Foreword, the Ministry of Foreign Affairs consulted this Department on the matter of the Draft UNESCO Convention on the Protection of the Underwater Cultural Heritage. The Department's observations and recommendations were forwarded by the Ministry of Foreign Affairs to those who were watching Sri Lanka's interests at the meeting. This is a very healthy sign for further co-operation with the Foreign Ministry on matters this Department can advise on.

**Acknowledgements**

Although this has been a long Foreword to the Report, I have tried to explain the nature and significance of the 1996–97 season. I have also thought it necessary to touch on the new powers the Department has been given and the likely effect of these changes on maritime archaeology in Sri Lanka. We have come a long way since 1992 and it is up to us now to go forward with greater confidence. Finally, I must thank those who made this season's work possible: Lieutenant Commander Somasiri Devendra, Gihan Jayatilaka and Nerina de Silva (the Sri Lankan Consultants), Dr Ananda Gunatilaka, Professor Jeremy Green, Karen Millar and the rest of the team from the Departments of Maritime Archaeology and Materials Conservation of the Western Australian Maritime Museum and the Australian National Centre of Excellence of Maritime Archaeology, Robert Parthesius of the University of Amsterdam, the Sri Lankan archaeologists and conservators undergoing training in maritime archaeology and conservation, Mr Senarath Liyanapathirana of the Central Cultural Fund and Dr Moira Tampoe of the University of Peradeniya. I must thank the staff of my own Department who were attached to this project for working under difficulties in an area not familiar to them—particularly Mr Senarath Dissanayake (Director, Exploration and Documentation), and the staff who had to provide the administrative and logistical framework for the operation. I also wish to acknowledge the great help and assistance of Mr Sirinimal Lakdusinghe, Director, Department of National Museums and Mr Kandamby, Curator of the Galle Maritime Museum; and of Professor Senake Bandaranayaka.

S.U. Deraniyagala
Director General
Department of Archaeology

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# PREFACE

Producing a book like this is not an easy job. The editors have the responsibility of ensuring that there is consistency in style while keeping the sense that the contributors intended. This problem is compounded because the work covers a number of different disciplines: archaeology, history, conservation, education, cultural resource management and remote sensing.

The two editors, one in Australia and one in Sri Lanka have not had an easy task, since distance and our other priorities have, at times, slowed the production of this work. Additionally, the various authors too have all had their own responsibilities, so that the collation and writing has proceeded in fits and starts. However, the access to email has made this task much easier and more efficient. The various sections written by the authors have been combined by the editors to form—it is hoped—a unifying whole. Robert Parthesius has written the sections relating to the historical background and history of the sites. He has attempted to integrate, as far as this is possible, the archaeology and history of the sites. During the 1997 programme he was responsible for the work on Site G in conjunction with Dena Garratt and in addition developed the section on the *Avondster*. Karen Millar reports in detail on the training aspects of the project that took place during 1997, indicating the extent and nature of the programme. The training has always been a difficult issue with the Galle Project, the trainees have to be seconded from other agencies and there is no clear structure within the Archaeology Department for the trainees. However, both the Department and the Project are committed to providing appropriate training for Sri Lanka in order that it can manage its own underwater cultural resources. Corioli Souter, who was responsible for the project on the stone anchor site in 1997 writes on Sites P and T. The stone anchors provide one of the most interesting non-European links with Indian Ocean trade. The unusual discovery of wooded arms to the so-called Arab style anchors will provide an interesting opportunity to date these particular anchors. Again the discovery of the 'Mediterranean style' three-holed stone anchor adds to the growing corpus of anchors of this type in the Indian Ocean. Vicki Richards and Jon Carpenter write on conservation aspects for the main part of the work and, in addition, provide more detail in the appendixes.

As explained by Deraniyagala in the Foreword, the Galle Harbour Project has had a unusual and varying history and this report marks an important turning point for the Project. While many of the sites have now been identified and studied in a preliminary way there is need to develop an on-going programme. It is hoped that this report will act as a basis for the future.

# INTRODUCTION

*An oruw fishing in Galle Harbour*

The Joint Sri Lanka–Australia Maritime Archaeological Research Programme (in 1996 it became Sri Lanka–Australia–Netherlands), centred in the World Heritage–listed Galle Harbour precinct, has conducted underwater archaeological surveys in 1992, 1993, 1996 and 1997 (Green & Devendra, 1993i, 1993ii; Green *et al*, 1992). The genesis of the Joint Sri Lanka–Australia Maritime Archaeological Research Programme came about in discussions between Professor Kenneth McPherson, then of the Indian Ocean Centre for Peace Studies at the University of Western Australia; Professor Senake Bandaranayaka, Director of the Postgraduate Institute for Archaeology (PGIAR) in Sri Lanka; and Dr Roland Silva, then Director-General of the Central Cultural Fund (CCF) in Sri Lanka. It was proposed to establish a research and training programme in maritime archaeology in co-operation with staff from the Western Australian Maritime Museum's Department of Maritime Archaeology (DMA).

Subsequent discussions on the proposal, which took place between McPherson and Green, led to a tentative programme being formulated. This draft proposal underwent further refinements, in conjunction with Bandaranayake and Lt Cdr Somasiri Devendra of the Maritime Heritage Trust (MHT), before the programme was finalised in February 1992, in readiness for the first season of field-work which started in March of that year.

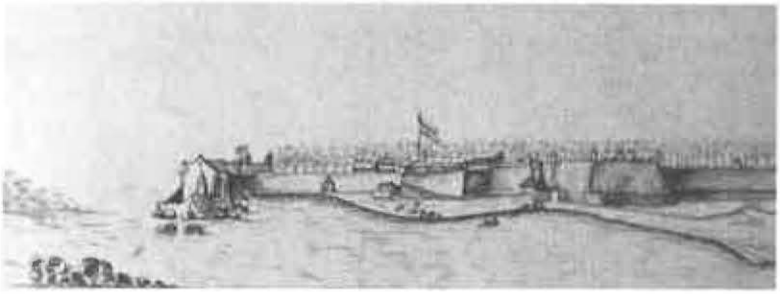
Devendra was the Sri Lankan co-ordinator for the programme from 1992 to 1997. As all archaeological work in Sri Lanka requires the approval of the Sri Lankan Department of Archaeology (SLDA), this organisation also became a member of the programme. Funding in Sri Lanka in 1992 and 1993 was provided by the PGIAR and the CCF, and the programme was supported by volunteers from the Sri Lankan Sub Aqua Club (SLSAC). The Project also received input from the Sri Lanka Archives and the Department of National Museums (DNM).

After the 1993 season, it was decided to make this a continuing programme and it was included in the Integrated Study of the Silk Routes programme. As a result of the advanced state of planning for the proposed development of Galle Harbour as a container terminal, State funds were specially passed by a Cabinet Paper, then channelled through the SLDA, to assist in a survey-and-rescue archaeology programme. From 1996 the SLDA exercised complete managerial control, although the trainees came from the CCF and the DNM. In 1996 there was no specific training component, but in the October 1997 season, training was again incorporated in the programme.

Since 1996 the Project has directly involved the Department of Economic and Social History of the University of Amsterdam (UvA) and the Amsterdam Historical Museum, initiated through an informal involvement with historians Robert Parthesius (since 1992) and Dr. Lodewijk Wagenaar (since 1997).

The Australian contingent originates from the Western Australian Museum and consists of staff from the DMA and the Department of Materials Conservation, as well as volunteer specialists from Australia and elsewhere. The Australian involvement in the Galle Harbour Project is currently an Australian National Centre of Excellence for Maritime Archaeology initiative, under the direction of Professor Jeremy Green. Australian funding for the Project was provided by the Centre of Excellence, the Western Australian Government and the Australian Department of Foreign Affairs and Trade. From the Netherlands the project has been supported by the University of Amsterdam and the Amsterdam Historical Museum. The Project has also been supported by Fugro Survey, Australia.

# HISTORICAL BACKGROUND



*17th century drawing of Galle*

Galle was a port in pre-Christian times but gained in importance after the 12th century. By the 14th century, it was one of the (if not the) most important ports on the south-western and southern coasts of Sri Lanka. By the time of the arrival of the Portuguese, Galle had become a major *entrepôt*, but it achieved greatest prominence with the growth of Dutch power in Sri Lanka. Galle remained the major port in Sri Lanka even after the arrival of the British in 1796. It was only in 1873 that the present port of Colombo came to be constructed, leading to the decline of Galle.

Galle was the second most important harbour of the *Verenigde Oost Indische Compagnie* (VOC), the United Dutch East India Company, in Asia. After capturing Galle from the Portuguese in 1640, the Dutch established a firm base for their cinnamon trade in Sri Lanka. Up to 1796, when the English took over the city, the fortified port was an important hub of trade and shipping. Galle was strategically located for traffic between the Arabian peninsula and East Asia, but it also played an important role in local and regional trade. There is extant a rich archival source of Dutch historical and iconographic material. Also, several ships of the VOC have been wrecked in or around the Bay of Galle.

Aside from their intrinsic archaeological significance, the VOC wrecks in Galle Harbour and its vicinity offer a prime example of an interactive research process which utilises history and archaeology. The presence of four (possibly five) identified and well-documented wrecks within the context of one harbour offers the potential for a broad interdisciplinary study of the ships, the harbour, the city and the organisation of the VOC. In an even broader perspective, this study can be related to questions about the Asian shipping network and its organisation.

This interdisciplinary approach continues a tradition of integrated historical-archaeological research on VOC ships. Since the 1970s, the Western Australian Maritime Museum has been conducting research on four East Indiamen wrecked on the Western Australian coast. In each case, historical information about the ship, crew and cargo has been linked with archaeological information.

Galle has an unusual collection of VOC wrecks, representing several types of ship in use by the VOC during the period of their presence in Sri Lanka. These wrecks can be linked, in a multidisciplinary research programme, with the administrative records that survive in the National Archives of Sri Lanka (SLNA), the VOC archives in the Netherlands, and other Dutch archives in India. The SLNA, in Colombo, contain the so-called Dutch Records, which cover the period from 1640 to 1795, including the administration in Galle (Jurriaanse, 1975). The combination of shipwreck archaeology with archival information on the harbour and shipping provides an important opportunity for both a general study about trade and shipping, and a detailed study of the specific ships wrecked in the harbour.

Such a study could be structured in four parts: the use of the harbour; local shipping and trade in the Gulf of Bengal; inter-Asia shipping and trade; and direct trade and shipping between Sri Lanka and Europe. Detailed questions may be posed about the following:

- Ship types in the inter-Asia trade, and in trade between Asia and Europe (both European and local vessels);
- Technical development during the 17th and 18th centuries; and,
- Organisation of the shipping in the harbour: repairs, equipment, crew, etc.

The Bay of Galle forms a natural harbour, protected from the north-east monsoon, but exposed to the south-west monsoon. Entrance to the bay was dangerous because of the many submerged reefs and rocks. Of the six VOC ships known to be sunk in or near the harbour, three were wrecked during the vessel's arrival or departure; two were sunk within the harbour (one by an explosion at anchor, and the second after coming adrift from her anchor); and one was wrecked outside the bay while waiting for the pilot to bring her in. The wrecking of these ships is well documented. This present report documents the archaeological research carried out to date in the context of the broader historical relationship between local shipping and trade; inter-Asia shipping and trade; and direct trade and shipping between Sri Lanka and Europe.

# GALLE HARBOUR SITE DESCRIPTION

*A view of the Hercules wreck site*

Four seasons of diving investigations in Galle Harbour have provided considerable insight to the underwater environment in the Bay of Galle. The sea bed is comprised mainly of rock, with some sand and sediments which, in some locations, were seen to overlie mud deposits. Deposition of mud is probably a consequence of the earlier flow of rivers into the bay. The bay exhibits dispersed outcrops of rock, comprised, in most instances, of boulders varying in size and extent of coverage. Sand and sediments vary in grain size, with coarser sands along the entrance of the bay. Finer sediments persist in the usually less turbid areas to the western side of the bay and, more extensively, in the more protected waters of the eastern side. Through the central zone of the bay, mounds of coarser sand have built up alongside finer sediments. In some instances, these areas have become the focus for accumulations of artefacts.

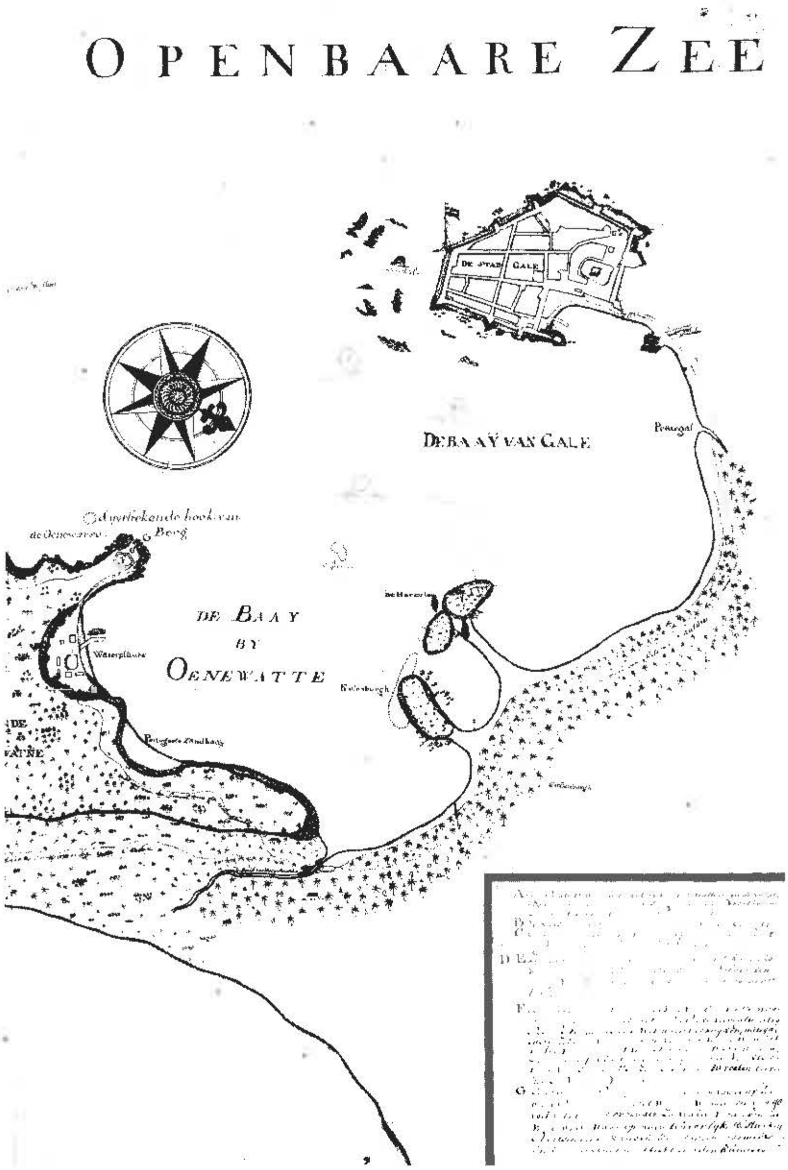
The shore-line of the bay presents itself in three forms: a wall of rock; a sand beach; or a combination of the two. The environmental conditions influencing wreck sites in each of these zones vary accordingly. There are, also, mostly unquantifiable influences and overriding factors which may have affected any of the sites, i.e. the unpredictable extent of salvage, looting, anchoring damage, and disruption and covering by harbour works (wharves, etc.).

Galle Harbour has extensive naval and urban developments on its coast-line. The harbour acts as a port and a base for professional fishing operations. Disposal of effluents may have lead to the pollution of the surface sediments in the harbour. Pollution will directly affect biological activity and the growth rate of fouling assemblages, which are important in shipwreck deterioration.

Sri Lankan Sub Aqua Club divers, having made underwater observations in the bay following the monsoon season, report of considerable upheaval of the sea bed, with consequent exposure or covering of shipwrecks and dispersal of artefacts. It is usually only possible to assess the extent of sea bed and wreck site disturbance when the monsoon and storms in general are over. Expeditions are planned to avoid the monsoon seasons for obvious reasons. In-between monsoon seasons, wreck site exposure variation is determined during excavation by ascertaining the depth at which sediments under the sea bed appear to be stable, i.e. compacted (firm), discoloured (usually blackened) and, therefore, usually anaerobic (no oxygen). Burial restricts general marine life colonisation and inhibits the development and destructive activity of marine borers. The extent of infestation of ships' timbers, the animals' stage of growth (shell size), and whether or not living examples are present (e.g. the presence and size of dead or living barnacles attached to timbers) will help to determine exposure and burial cycles.

During the months October–November 1997, the underwater visibility in the Bay of Galle was generally poor, frequently 0.0 – 0.5 m, occasionally 2.0 – 3.0 m, and consistently less than that of previous visits (January–February). Water temperature has remained much the same at 30°C at the surface and 29°C at depth.

# EARLY FIELD-WORK




*An undated 17th century map of Galle showing the Hercules wreck (ARA VEL 1056)*

## Field-work in 1992 and 1993

Bandaranayake suggested Galle Harbour as the programme's initial survey area because of the large number of shipwrecks known to have occurred in the bay, and because of the possibility of a harbour facilities development that would endanger underwater archaeological sites.

The main objectives of the programme were outlined for the team by Bandaranayake in Colombo at the start of the first season in 1992. The goals were threefold: establish a database or Geographical Information System (GIS) of shipwreck sites in Galle Harbour; investigate these sites where appropriate; and train archaeological students in the theory and practice of maritime archaeology. The maritime archaeological field-work programme proceeded along these lines and a total of nine sites were recorded by the Galle Harbour Project in 1992. These sites were initially designated, consecutively A–J (Site I was known about in 1992, but was not located until 1993).

Initially, the most valuable source of information on the location of sites was the local fishermen. Often, only the general proximity of a site was known, thus underwater searches were required to locate the sites. Once a site was located, its position was accurately recorded. A pre-disturbance survey was then conducted to determine the significance of each site and, therefore, the potential for further archaeological investigation. As part of the Galle Harbour Project, a study of a model of a *yatra dhoni* housed in the Maritime Museum in Galle was carried out by Tom Vosmer (1993), and an investigation was made of the surviving chine strake of a *paruwa* at Lathpadura (Green & Devendra, 1993ii).

The sites in Galle Harbour discovered during the 1992 season included $19^{th}$-century or later iron shipwrecks (sites A, B, C and D); wooden *c.* $19^{th}$-century shipwrecks (sites E and G); the VOC shipwreck *Hercules* (1661) (Site F); a pair of abandoned cannon (Site H); and a jettison site (Site J).

All material collected during the survey was registered on a computer-based artefact registration system. Every item was given a registration number which included the code GH for Galle Harbour, a site designation code (A–J) and a number. Additional information recorded included a material code, number of items, description, date of collection, location on site, photographic and drawing requirements, dimensions and conservation requirements. During the first season, Sri Lankan archaeologists Dr Moira Tampoe, of the University of Peradeniya, and Dr Martha Prickett-Fernando, of the Institute of Fundamental Studies, assisted the Project with the classification of the artefacts recovered. Their report was published in Green and Devendra (1993ii).

Following the 1992 season, archival research was initiated by Robert Parthesius (UvA) in the Netherlands to help identify what was thought to be a VOC shipwreck (Site F). Parthesius found a map of the Bay of Galle with the *Hercules* (the name of a VOC ship wrecked in 1661) marked in the same position as Site F.

The second season, in 1993, continued the work of the first season, with additional survey of existing sites and investigation of new sites. Four new sites were located: sites I, J, K and L. The new sites, I and K, were iron shipwrecks; Site L was the wreck of another, well-preserved VOC shipwreck, thought to be the *Avondster* (1659); and additional areas of Site J, which was found in 1992, were located. Also, at the invitation of the SLDA, a brief investigation was undertaken of the wreck site at the Great Basses—a site discovered and investigated by Arthur Clark and Mike Wilson in 1963. In addition, preliminary conservation pre-disturbance surveys were performed on these shipwreck sites to assist in obtaining a clearer understanding of the nature of the degradative forces operating on the sites. This would assist in later excavations and the establishment of effective conservation management programmes for these shipwreck sites (Green *et al.*, 1993).

**Archaeological overview of the 1992 and 1993 seasons**

The timbers of the *Avondster* (Site L), found just off the gently shelving sand shore-line, have survived remarkably well. The more modern Site E has less surviving timber than the *Avondster*, but this may be the result of extensive salvage in the past. It is anticipated that a wide range of artefact materials will have survived on the *Avondster* site because of the overall integrity of the site. This is in direct contrast to the *Hercules* (Site F), which lies scattered across the boulder-strewn underwater slopes of Gibbet Island, and has, in terms of structure, totally disintegrated. Only durable artefacts survived, such as cannon, and the ship's bell recovered in 1992. The wooden vessel wrecked at Site G lies at the bottom of a rock-faced shore-line, but it is exposed to the calmer conditions on the eastern side of the bay. It was anticipated that much more of this vessel would have survived—in fact, little of it remains. It is presumed that the site was extensively salvaged. This site was affected to greater extent by swell and surge during the 1997 October–November expedition but in general the site is more protected.

Across the wide entrance and central area of the bay, no evidence has been found of the structural remains of wooden-built shipwrecks. Iron shipwrecks in this zone are substantially intact below the water-line, but generally most of the vessel sides have collapsed, and no superstructure exists. There is evidence of extensive salvage activity, as engines have been removed and boilers broken open. Closer to the sandy shore, remains of the iron ship at Site A are quite substantial, despite the water turbulence and shallow water depth. The artefactual and shipwreck evidence suggest the environmental conditions that generally prevail along and just off the sand shore-line are more conducive to preservation.

As part of the Galle Harbour field-work programme, a group of Sri Lankan archaeology students were given archaeological and conservation training (see below). For details of these two seasons' work and the training programme see Green *et al.* (1993).

**The Galle Harbour Development**

Since 1989, the Government of Sri Lanka had been considering plans to develop a container terminal in Galle Harbour. In 1995, a plan was accepted and the contract for construction awarded. As a result of this, an urgent request was made in mid-1995 to begin planning a complete survey-and-rescue archaeological operation in Galle Harbour, in the areas that were to be affected by the development either by infilling or dredging.

*The Black Fort*

A three-stage programme of field-work was proposed, with the first two stages planned for completion in 1996:

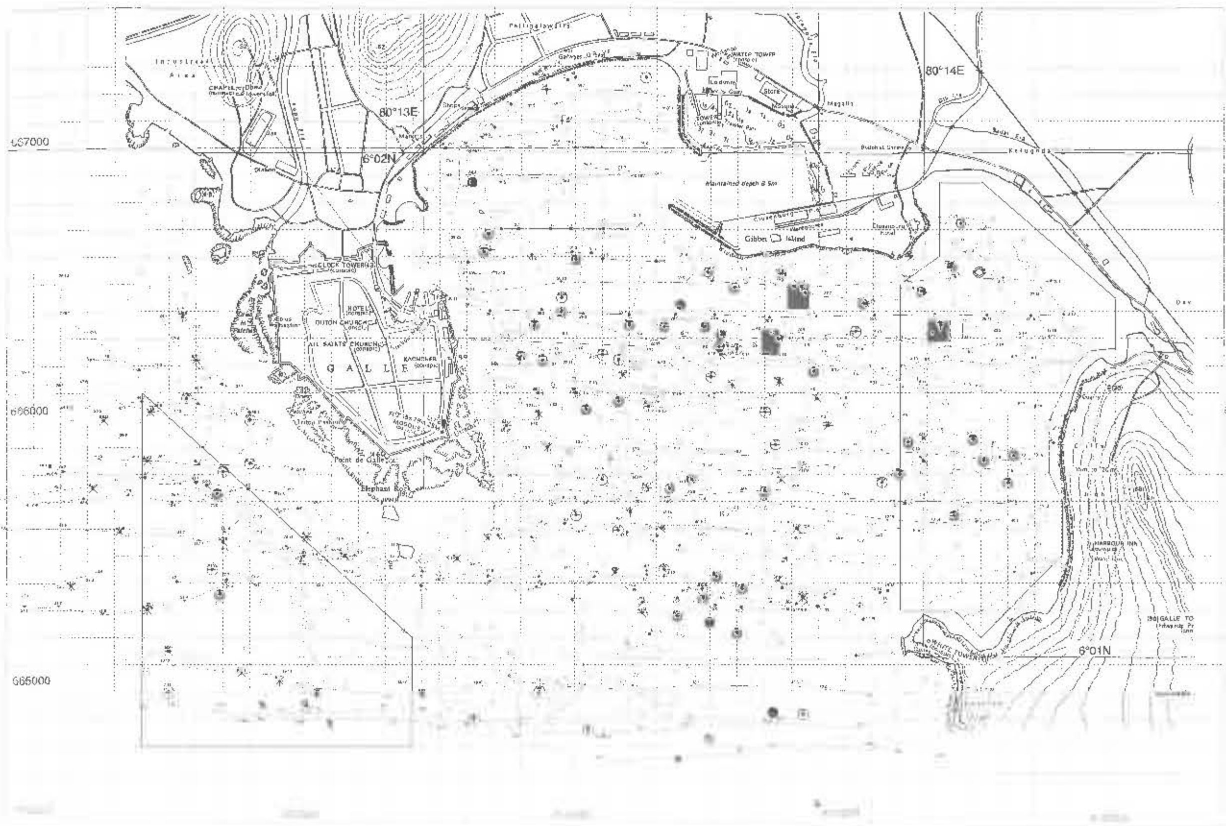
Stage I — Remote sensing (side-scan sonar) survey of the harbour to identify and locate wreck sites that lie on the sea bed.

Stage II — Investigation and survey of sites discovered in Stage I and further archaeological investigation of known sites (E, J and L) to determine extent and preservation. Archival research to determine more about the sites located.

Stage III — Proposed for 1997. Rescue archaeology programme appropriate to the outcome of stages I and II, and dependent on the development of conservation facilities in Galle.

The following report describes the work that commenced in 1996, continued in 1997 and is still on-going.

# FIELD-WORK PROGRAMME 1996




*1996 plot of side-scan sonar tracks showing sonar targets*

**The sonar survey**

The first part of the 1996 field operations was a side-scan sonar survey of the harbour. This work was conducted over a two-week period from the Dakshina Naval Base. The survey team was based at the Port Authority's Circuit Bungalow in the Inner Harbour at Galle. An EG&G side-scan sonar—loaned to the Project by Fugro Survey, Australia—was deployed on a small, Sri Lankan Navy work-boat. The side-scan was towed from the front of the vessel in East–West tracks 100 m apart. The course of the vessel and, thus, the track was determined using a differential Global Positioning System (GPS) which gave the position of the vessel to an accuracy of about ±4 m. The system consisted of a Magellan Pro 2000 GPS and an Omni Star satellite-based differential system. The signals from the Omni Star were fed into the Magellan to give real time differential accuracy and the data was then fed into a Macintosh PowerBook 5300 to provide data logging.

The field operation consisted of a five-person team on the boat assisted by a Sri Lankan logistic team on land. The boat team consisted of a Sri Lankan Navy boatman, a side-scan operator, a GPS operator, a log-keeper and a side-scan sonar transducer handler. The log-keeper called 'fix' every 60 seconds, at which the side-scan operator marked position and time on the trace; at the same time, the GPS operator called the co-ordinates, and the log-keeper noted co-ordinates alongside the time as an additional hard-copy record. In general, the GPS operator directed the boatman to keep the vessel on course and directed the beginning and end of runs.

The survey covered Galle Harbour and the outlying areas from Watering Point to Kadda Rock and on to Kakoni Rocks; from there, east 1000 m and then north to the mouth of Kepu Ela, but excluding the modern Closenburg Harbour. A total of 48 runs were completed, covering a distance of 312 km. The sonar record covered an area of the sea bed 100 m on either side of the track of the vessel so that the total area of sea bed covered was 62 400 000 m2. The side-scan produces a paper trace showing a plan of the sea bed (in this case, 100 m on either side of the track). This record was carefully analysed and annotated, and the GPS co-ordinates in UTM (Universal Transverse Mercator) were noted on the trace at each fix. Each run was thus numbered, and each fix was also numbered. In addition, the data logging was processed using the Magellan software to provide a continuous track of the vessel. The analysis of the sonar trace then identified targets that were sites of potential archaeological interest and these were allocated consecutive target numbers. Using a CAD (Computer-Aided Drawing) package, a large-scale map of the area was printed up at a scale of 1: 5000, and the tracks of the vessel were generated using the data from the data logger and then pasted onto the CAD plan. The calculated positions of the targets were then plotted on the map. A total of about 160 targets were noted for investigation.

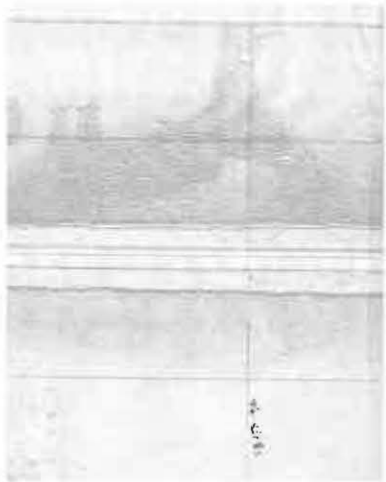
**Investigation of targets**

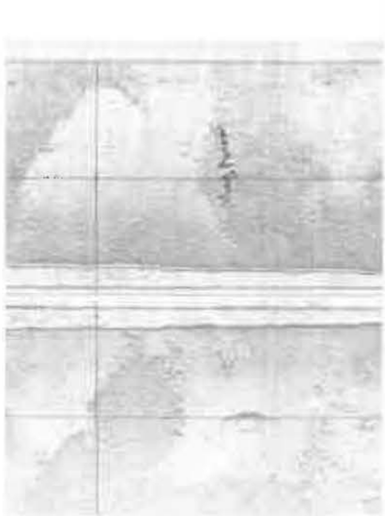
The second phase of the 1996 field-work (Stage II of the programme) followed almost immediately upon the first, with work being carried out over a 20-day period. An additional team, comprising Sri Lankan, Australian and Netherlands volunteers and staff, were brought in to assist with the diving operations. The Project was based at Nooit Gedacht Hotel, Unawatuna, and diving operations were carried out from the Sri Lankan Navy Base. Due to the military situation in Sri Lanka in 1996, the Navy Zone covered the whole harbour area, including parts of the Fisheries Wharf which had been the Project's diving base in 1992 and 1993. The new Navy zoning prohibits recreational and commercial diving in the whole of the harbour area, substantially reducing local collecting activities on the wreck sites. Targets were listed in priority of significance, generally based on size and structure. On each day, a survey team was sent to locate the identified targets using the differential GPS, and to mark each target site with a buoy. A diving team would investigate each target site in turn and produce a report on it. If the site was considered to be of archaeological interest, it was designated by a site identification code. The results of the diving showed that many of the targets were rock outcrops, but a significant number were sites which warranted further investigation. At the end of Stage II, 21 such sites had been identified: three wooden wreck sites, thought to be European (17th or 18th century); a cannon site known to be the VOC ship *Hercules* (1661); a group of two cannon (possibly a mooring); two stone anchors; a site where ceramics were found in large numbers, but it is uncertain if this is a wreck site or a jettison site; and a number of iron anchors and iron wrecks, which formed the remainder of the recorded sites.

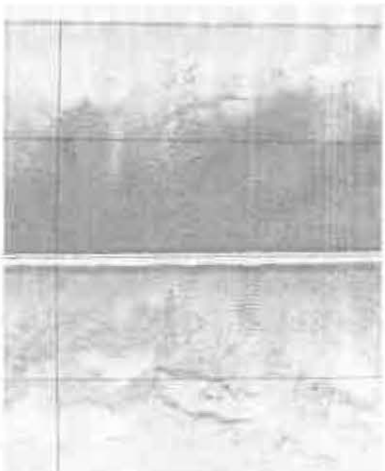
**1996 conservation overview**

During the 1996 expedition, an extensive conservation pre-disturbance survey of Site L (*Avondster*) was performed. The results of this survey are presented in the '1996 Conservation Management Report—Site L' (Appendix 1). Sites A, E, F and G were free-dived to ascertain any qualitative changes that may have occurred since the last expedition. Few changes were observed on these sites; however, the dives were very short, visibility was low and extensive surveys were not carried out.

Conservators were included in the survey diving teams that investigated and reported on each target site within and around Galle Harbour. During the period, Indrani Fernando carried out conservation of recovered artefacts. Very few artefacts were recovered, with the majority of material being ceramics, porcelain and clay pipes. In view of the proposed harbour works, it was recognised that there was a need to establish a conservation laboratory in the Galle area dedicated to preserving maritime archaeological artefacts. After preliminary investigations by conservators, a building located near the Maritime Museum on the shore-line of Galle Harbour, just east of the Black Fort, was chosen for the site of a new conservation laboratory. A report entitled 'A Maritime Archaeological Conservation Laboratory in Galle, Sri Lanka' outlines the suggested requirements for establishing such a laboratory (Appendix 2).







*Side-scan sonar records of the targets found during 1996 survey*

# FIELD-WORK PROGRAMME JANUARY 1997


*View of Galle*

**Archival research in Colombo**

In addition to archival research by Parthesius in the Algemeen Rijksarchief in The Hague in 1992 and 1993, research was conducted by Parthesius and Lodewijk Wagenaar (Amsterdams Historical

*VOC Coat of Arms on the gateway of the Water Port*

Museum) in the Dutch Records in the Sri Lanka National Archives in Colombo (SLNA) in 1993 1996 and 1997. The aim was to find more information on the VOC wrecks which were known to have been wrecked in the Bay of Galle but which had not been identified during the surveys in 1992, 1993 and 1996.

The following records are of interest for shipping to and from Galle in the administration of the VOC in Sri Lanka: ordinary minutes (1640–1796); drafts of the ordinary minutes (1764–1796); annexes to the ordinary minutes (1752–1796); circulated minutes (1767–1792); secret minutes (1781–1783); and annexes to the secret minutes (1792–1796).

Research in 1997 concentrated on the wrecking of the *Geinwens* (1776) and on finding additional information about the *Avondster*. Some information about the loss of the *Dolfijn* (1663) and the *Barbesteijn* (1735) had already been found in the Algemeen Rijksarchief in the Netherlands. Based on this information some hypotheses were formulated on the possible position of the ships *Dolfijn*, *Barbesteijn* and *Geinwens*.

In preparation for the field-work, a general survey of the archives was made to investigate the potential for linking archival material such as equipment and cargo lists, and Instructions for the use of ships in Asia, with the evidence from the archaeological sites. In both the Netherlands and the Sri Lankan archives, detailed information is available at this administrative level.

In the future, a scheme will be formulated to extend the training programme to archival research. Within the SLNA, two archivists have been trained to read Dutch at the Erasmus house, a Netherlands research centre in Jakarta. It is hoped to increase the number of Dutch-reading students and to encourage scholars to conduct practical research projects. Additionally, it is planned to begin researching 19th- and 20th-century archives to identify the later wrecks. The harbourmaster's archives and newspapers are likely to contain relevant information on the identification of shipwrecks in Galle Harbour (see also Green & Devendra, 1993 i).

*The old Packhuis of the VOC now the Maritime Museum*

# FIELD-WORK PROGRAMME FEBRUARY 1997

**Additional magnetometer and side-scan survey**
At the end of the 1996 season of field-work, concern was expressed that the side-scan sonar record of the harbour was not complete. In addition, it was thought that alternative methods of remote sensing should be assessed to examine the potential for buried sites. In February 1997, a further small-scale survey was carried out over a period of 14 days.

The objective was to survey the areas missed in the side-scan sonar survey in 1996; to investigate areas of particular interest; and to use a proton magnetometer to investigate sandy areas which might contain buried sites incapable of detection by side-scan sonar. The GPS receiver was a new multi-channel Trimbel ScoutMaster, which provided continuous position tracking. In the 1996 season, problems had arisen with the older type of GPS which could only track four satellites at a time. When any one of the satellites moved out of view, the GPS had to search for a new satellite, and during this time positions could not be recorded. The new system avoided these difficulties and allowed position logging every second. During this survey, the position was not hand-recorded. Instead the GPS was set to read out in UTM co-ordinates; hence the operator was able to plan East–West or North–South runs at intervals of a fixed number of metres, while the machine fed latitude and longitude to the data logger.

This position-fixing system was more sophisticated than that used in 1996, giving a positional accuracy of ±3 m in the North–South direction and ±5 m in the East–West direction. The side-scan sonar was deployed over the bow of the Navy work-boat; the proton magnetometer was towed about 12 m behind the boat.

The crew consisted of a boatman (Navy); the GPS operator who 'conned' or directed the boat on the pre-determined tracks; a time-keeper who called the time every 60 seconds; a magnetometer operator; and a side-scan sonar operator. Time was set to the GPS time; and as the time was called out every 60 seconds, the side-scan sonar and magnetometer operators respectively marked the time codes on their traces.

On completion of the day's survey work, the paper traces were recovered from the magnetometer and side-scan sonar, and the data from the logger was run through a statistical analysis software package to produce a bivariate line plot. This was scaled to fit with a graphics package which was being used as a low-level GIS. This was then placed in the programme in layers

*Magnetometer recorder in operation of the survey boat*

*Magnetometer trace showing anomalies and time codes*

*Tom Dawson monitoring the side-scan sonar recorder*

*Macintosh PowerBook logging data from the GPS system*

*Trimble ScoutMaster showing DGPS position*

*Recovering the side-scan sonar fish on the survey vessel at end of days work*

on a daily basis, enabling the track of the vessel to be monitored.

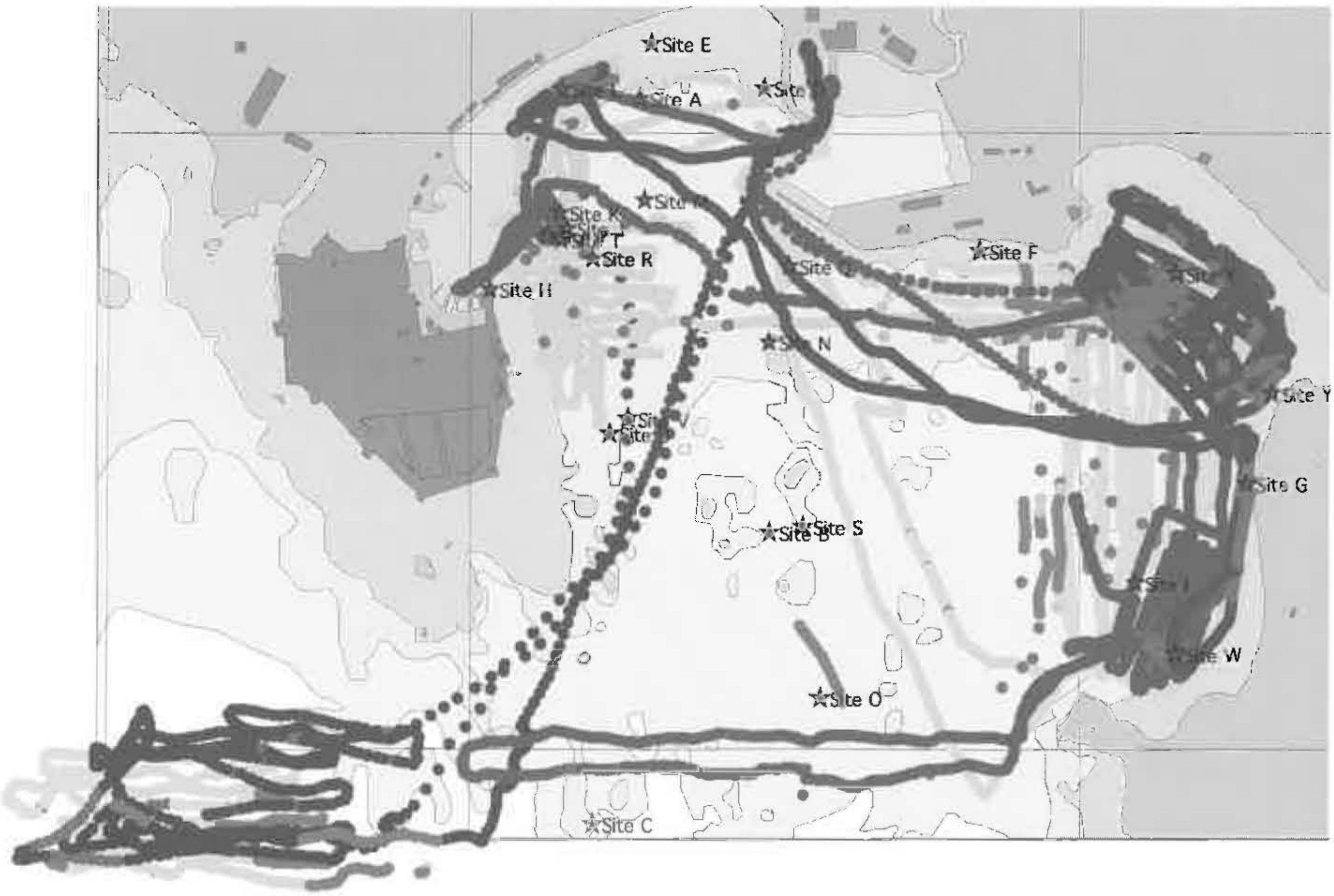
Once again, Fugro Survey, Australia, provided the EG&G side-scan sonar and the Omni Star differential GPS system. The Western Australian Maritime Museum provided the ELSEC proton magnetometer, the Trimbel ScoutMaster GPS system, and a Macintosh Powerbook 5300 computer as a data logger. The SLDA provided resources and infrastructure to support the Project. The Sri Lankan Navy provided work-boats and facilities in Galle. The Australian Department of Foreign Affairs and Trade, through the Australian High Commission in Colombo, provided a grant to assist the Australian involvement in the Project.

Four main areas had been identified from the 1996 survey as warranting further investigation:

1. The east side of the harbour, from Watering Point to Closenburg, in the area most likely to be affected by the new harbour project and the site of the possible location of the *Barbesteijn*;
2. The west side, an area of known historical significance, between the Black Fort and the Navy Base breakwater.
3. The *Dolfijn* site, south of Point de Galle;
4. The area between Watering Point and Elephant Rock, missed in the 1996 survey.

During the first phase of the 1997 field-work, a total of 118 km of survey track was completed. The interim results of the survey revealed evidence of three possible new sites. Since it was not possible to carry out diving inspection of the sites due to time constraints, it was planned that during the second phase of field-work, divers would inspect the positions which had been located with the differential GPS during the survey. The Project would continue with the analysis of the data collected during the 1997 survey, and with preparing a plot of the sites of interest to be examined in the first phase of Stage III of the proposed Galle Harbour programme.

# FIELD-WORK PROGRAMME OCTOBER–NOVEMBER 1997




*The 1997 survey plot showing track of vessel during magnetometer and side-scan sonar survey*

## Survey work

During the October 1997 programme, remote sensing survey work was again carried out. It was revealed from Parthesius' archival research that at least two VOC shipwrecks were known to have been lost in the eastern part of the harbour. From the magnetometer work in February 1997, two potential targets were located and noted for future survey. In October the magnetometer was again deployed to search these areas; however, the two anomalies both turned out to be ambiguous. The anomaly in the south, near Watering Point, revealed large sections of iron wreckage. As a result, the whole area requires a detailed survey, and is a priority for the future. The anomaly in the north was examined by divers, and, while no shipwreck material was observed, the sea bed appeared to be covered with mineral sands which may have affected the signal. This area is also designated for further survey.

During the last few days of the season, a survey was started from the beach in the bay in the north-east of the harbour. The objective was to survey the shallow water, where survey vessels cannot operate and where the position of the shore line may have changed, as it moved further out to sea over time.

## Archaeological field-work

In October 1997 the work began with the investigation of sites which may be threatened by the proposed harbour development. These were Site G and the two significant magnetometer targets on the eastern side of the harbour recorded in February (see above). In addition, investigations were undertaken at the stone anchor site close to the Black Fort.

Site G was re-surveyed and a limited excavation of the site was carried out. Earlier accounts of the SLSAC had reported that some considerable hull structure had been seen uncovered in 1996 following the monsoon, although the exact position was not recorded. Searches were made for this structure but without success. For more detail, see the section on the archaeology of the sites below.

The large complete 'Arab-Indian' stone anchor found in 1996 was relocated and, during the search for the broken 'Arab-Indian' anchor from 1996, two new anchors were found. One

*Large stone anchor recovered during the 1997 season*

anchor was a local piece of granite with a hole (possibly a drill-hole from blasting) and a chain attached. The other anchor was an interesting four-holed stone anchor of the type typically found in the Mediterranean. The anchor was a flat sandstone block about 1000 mm by 650 mm by 150 mm (thick). It had two round holes at the apex and two square holes at the base. All anchors were surveyed; two of them were raised and placed outside the Maritime Museum in Galle Fort. The anchors were deconcreted, photographed and drawn. Survey work in the area indicated timber structure under the large stone anchor and large quantities of loose artefacts in the area. During the final days of the season two more stone anchors were located: one a single-hole anchor; the other a broken 'Arab-Indian' style anchor. It transpires that the first broken anchor found in 1997 was not the anchor found in 1996 (some doubts had been expressed when it was first found that it did not match the measurements of the anchor found in 1996); the second anchor was identical in structure but slightly larger. An 18th-century admiralty-pattern anchor was also discovered.

As part of the 1997 programme, a more sophisticated GIS system was developed for Galle Harbour. The software package used was ArcView, which enables the integration of graphic and database information. The GIS information from previous seasons was incorporated in the ArcView system, and the application was used to integrate all graphical and database information into one single document. The system allows the user to view the whole of Galle Harbour and see site locations and tracks of individual runs during the remote sensing survey of 1996 and 1997. The user may then zoom in to each individual site and inspect each site plan with the linked artefact database. The system was especially useful for examining the spatial relationships between artefacts and for interpretation of the wider survey data.

**Conservation overview**

The conservation aspects of the work undertaken during the October–November 1997 expedition are mentioned throughout the text. A short summary is presented here. The primary role has been, and continues to be, the provision of conservation support for the archaeological work undertaken. The conservation of recovered artefact materials has enabled a practical teaching programme, supported by lectures, to be carried out. The importance of *in situ* conservation and environmental assessments of underwater sites has also been emphasised and demonstrated. The training of Sri Lankan archaeological personnel to scuba dive has also been recommended for suitable conservators so these underwater aspects of conservation can be carried out. It is of paramount importance that recovered artefacts be stabilised and conserved. To this end, a dedicated conservation laboratory has been designed for Galle and is presently under construction.

**Maritime archaeological training programme**

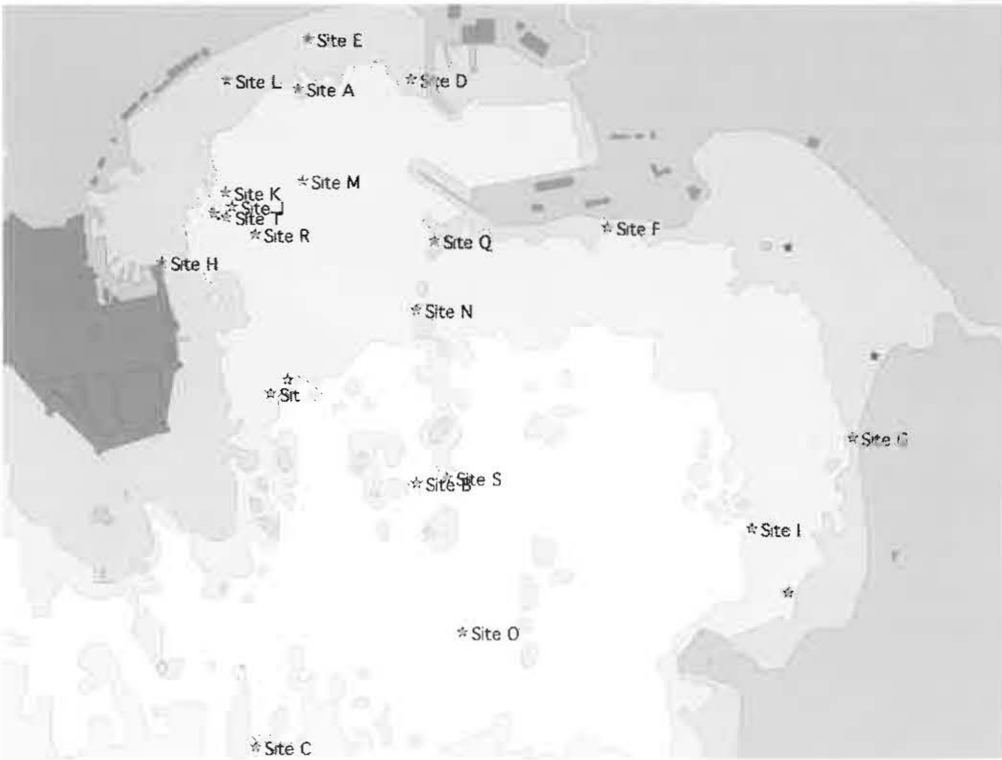
The rationale for including a training component in the Galle Harbour Project is to train the participants, who are predominantly involved in land-based archaeology in Sri Lanka, in maritime archaeological techniques. The first formal training programme was conducted in 1993; however, the intention to continue with the training in 1994 and 1995 was delayed due to lack of funding. Training resumed in the 1997 field-work season.

A group of eight trainees, all holding open water diving qualifications, participated in the 1997 programme. Students attended on a full-time basis, with the expectation that they would participate in additional maritime archaeological activities when not in formal training. Lectures were held in English with a Sinhala translation.

Each member of the Sri Lankan, Australian and Netherlands teams presented topics and tutored the students in their specific area of expertise. Throughout the 6-week period, the team combined site work with training on a rotational basis. The trainees benefited from this group approach by having access to maritime archaeologists and historians noted in their fields. The range of topics and skills covered were extensive, and included maritime archaeology, maritime history, technical skills (photography, surveying, shipbuilding, drawing etc.), conservation and scientific diving techniques. The trainees participated in every aspect of the 1997 Galle Harbour Project including on-site work conducted in the harbour. See Training Programme below.

# THE SITES

| Name | Type | Lat dec° | Long dec° | Mate-rial | Date found | General area |
|---|---|---|---|---|---|---|
| Site A | Large iron wreck | 6.034394 | 80.223295 | I | 1992 | N central harbour near marine terrace |
| Site B | Iron wreck | 6.0226314 | 80.226856 | I | 1992 | Central harbour |
| Site C | Iron wreck | 6.0147541 | 80.222056 | I | 1992 | Kadda Rock outer harbour |
| Site D | Iron wreck | 6.0346714 | 80.226675 | I | 1992 | W breakwater Fisheries Harbour |
| Site E | Wooden wreck | 6.035877 | 80.223611 | W | 1992 | N central harbour E of site A |
| Site F | VOC Hercules site | 6.030260 | 80.232545 | W | 1992 | S side of Fisheries Harbour, Closenburg |
| Site G | Wooden wreck with ballast mound | 6.023977 | 80.239845 | W | 1992 | E side of harbour near Harbour Inn |
| Site H | Two iron cannon | 6.029234 | 80.21924 | S | 1993 | Near Black Fort off Harbour-Masters Jetty |
| Site I | Iron wreck reported but not located in 1992 | 6.021277 | 80.236845 | I | 1993 | East harbour |
| Site J | Large area of ceramic shards | 6.0308771 | 80.221335 | S | 1993 | S Diyamba Lihini |
| Site K | Large iron wreck | 6.0313003 | 80.221143 | I | 1993 | S Diyamba Lihini |
| Site L | VOC Avondster site | 6.03465 | 80.221183 | W | 1993 | N central harbour W of Site A |
| Site M | Iron anchor | 6.031644 | 80.223445 | A | 1996 | Central harbour |
| Site N | Iron anchor | 6.027810 | 80.226845 | A | 1996 | Central harbour |
| Site O | Iron wreck | 6.018180 | 80.228233 | I | 1996 | South central harbour |
| Site P | Stone anchor site centre on large stone anchor | 6.030683 | 80.22080 | A | 1996 | SE Diyamba Lihini |
| Site Q | Wreckage | 6.029862 | 80.227383 | S | 1996 | S of S Fisheries Harbour breakwater |
| Site R | Iron anchor | 6.030060 | 80.222028 | A | 1996 | SE Diyamba Lihini |
| Site S | Wreckage | 6.022794 | 80.227761 | S | 1996 | Central harbour |
| Site T | Iron anchor | 6.030566 | 80.22083 | A | 1996 | S Diyamba Lihini |
| Site U | Iron anchor and wreckage | 6.025316 | 80.222500 | A | 1996 | E of Aurora Bastion |
| Site V | Wreckage | 6.025716 | 80.223000 | S | 1996 | E Aurora Bastion |
| Site W | Iron wreck | 6.019366 | 80.237933 | I | 1997 | Watering Point Bay |
| Site X | Target, possible wreck | 6.029650 | 80.237933 | ? | 1997 | Off Gommoliya Rks |
| Site Y | Iron wreck | 6.0264167 | 80.24053 | I | 1997 | Gravet Point |




*Plan of Galle Harbour showing sites located*

The following is a list of all sites located between 1992 and 1997. Some of these sites will be described in detail below. The locations are give in decimal degrees using the WGS84 datum. This datum was used since the Admiralty chart of Galle Harbour (Admiralty ??) has a Ceylon 1933 datum (Kandawala datum–Everest) and not common to GPS systems, thus plotting GPS co-ordinates directly onto the chart is not possible. To locate a WGS84 datum GPS position on the Ceylon 1933 datum chart, the position must be translated 238 m ENE 83.5°. Alternatively, in decimal degrees, to convert a Ceylon 1933 co-ordinate to WGS84 the point has to be moved 0.002128°E and -0.000227°N.

## Site G

*Cliff face at Site G*

*View of the site showing the nature of the sea bed*

*Timber found on site*

### Site description

The site lies in a NE–SW direction, perpendicular to a granite rock face. The wreck lies on a calcareous sand sea bed, with a gentle slope, interspersed with large granite boulders concentrated at the base of the rock face. The wreck site is characterised by the ballast mound and other smaller artefacts scattered amongst the stones. Changes noted at this site compared to previous years (Carpenter & Richards, 1993) would be explained by the swell and consequent surge which had produced a series of parallel sand waves alongside and encroaching on the ballast stones of the wreck site. Coarse sand and shell grit overlays finer sediments. Despite a thorough investigation of the ballast, only one piece of ships' timber was located. As with previously discovered timber on this site, it was degraded, soft and friable. Samples of the timber were not taken for identification and water content, as samples collected in 1993 had been previously analysed for these (Green & Devendra, 1993). The selection of artefacts recovered consists of ships' fastenings, sheathing, pottery and coal. All except a few of these were found exposed amongst the larger boulders that lie between the ballast and the base of the cliff.

### Archaeology and history

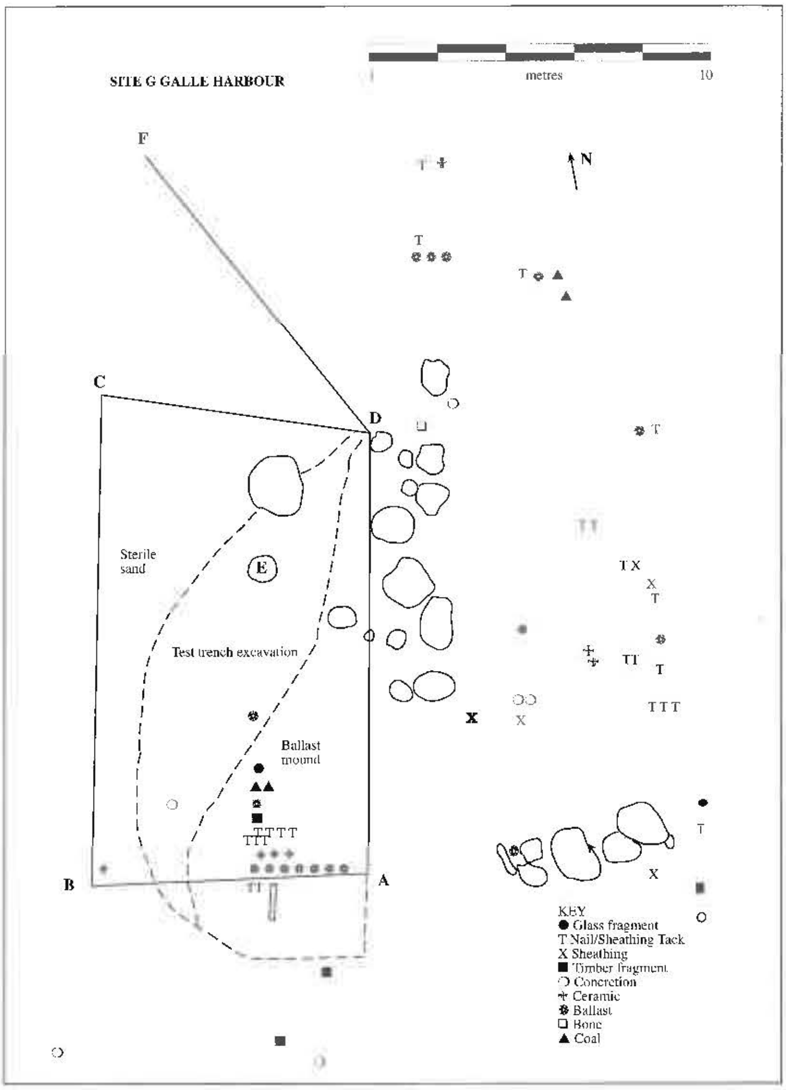
The VOC *retour* ships *Barbesteijn* and *Geinwens*

Galle was not only an important emporium, but a key staging post for European arrivals and departures. The Directors of the VOC in Europe accepted this port as a second rendezvous to Batavia. Ships normally arrived from the Netherlands in October–November, before going on to Batavia. They left Sri Lanka for the Netherlands either in November or in February. For this regular shipping between Europe and Asia, the so-called *retourschepen* (returning ships) were used. These ships were bigger than the ships in service within Asia. They could carry large numbers of people and large quantities of equipment on their way to Asia, and large cargoes of Asian products on their return. *Retour* ships arriving in Galle unloaded their products for Sri Lanka, underwent repairs, and loaded commodities for their onward journey.

In the Bay of Galle two larger *retour* ships were wrecked: the *Barbesteijn* (1735) while sailing into the harbour; and the *Geinwens* (1776) while sailing out of the harbour.

The *Barbesteijn* sailed on 18 October 1735 from Colombo to Galle. The normal procedure was for ships to anchor outside the Bay of Galle and wait for a pilot. The weather being too bad to enter the harbour, the *Barbesteijn* waited for a number of days. In the morning of 22 October, the ship broke one of her anchors and drifted in the direction of the shore:

> When the rope of the small bower broke we were driven to land. We fired distress-signals, in order to get assistance from the shore... There was a strong southerly wind with a high running sea from the south-west, at the 2nd glass both anchors broke and we fell with the bow to the NE in the direction of the shore, against all [instructions], we went into the bay with God's blessing. We were able to keep her above the *blaasbalg* (the SE corner of the bay), we sailed through a rough sea, the current dragged us into the bay. We used the foresail and spritsail and prepared the two kedges. We dropped the anchors inside the *klip van negen* (submerged cliffs in the middle of the bay),...we still couldn't fix the ship we dropped another kedge, in the end we trying to stop the ship by throwing guns on ropes overboard, we also saw a boat with anchors but it couldn't reach us, after a little while we hit the bottom. This was about 8 hours, till 9 hours we weren't leaking, due to the constant bumping we first made water and later also sand. At the evening there was water up to the first deck that night we made water up till two feet between the decks. In the meanwhile they tried everything from the shore to help us, it was useless the vessels and the *thonij* [local vessel used for piloting] capsized in the breakers.



Site plan

## Location of the *Barbesteijn*

The *Barbesteijn* may have been found during the magnetometer survey in February 1997. A target was found close to the beach in the north-east corner of the bay of Unawatuna.

## Location of the *Geinwens*: Site G

After earlier surveys in 1992 and 1993, it was decided to continue the survey of Site G in 1997. Site G is one of the sites which may be affected by construction work for the proposed new container terminal. The work done on the site must be seen as a form of rescue archaeology.

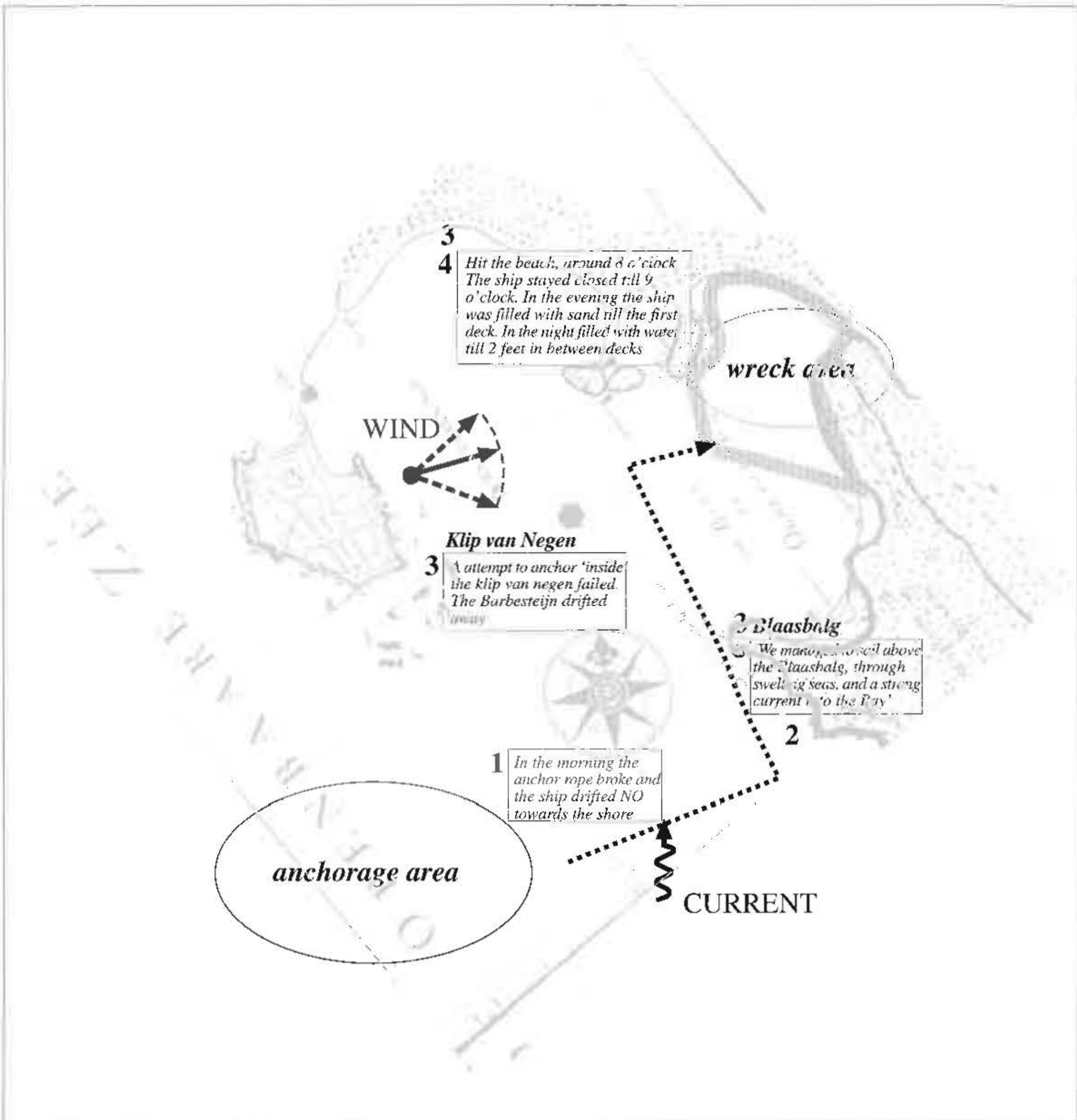
There were also other reasons to start new research at Site G. Archival research conducted in January 1997 in the Dutch Records of the SLNA, in Colombo, suggested the possibility that Site G was the wreck of the VOC ship *Geinwens*.

## Historical indications for an identification of the site as a Dutch ship

The archival research in January aimed to discover any information about the location of the VOC ships known to be wrecked in or near the Bay of Galle. An account of the wrecking of the *Geinwens* in 1776 gave rise to the suspicion that this could be Site G.

In a letter to the Netherlands from the VOC government in Colombo, an accident involving the ship *Geinwens* was reported (SLNA 1, 949.).

The *Geinwens* was preparing to sail for Cochin to load pepper and then to sail to the Netherlands; she loaded cinnamon and cloth in Galle. As the ship was departing from Galle on 23 October 1775 it struck a submerged reef. Within hours the ship was refloated but was leaking badly 'The water had raised till nine *voet* [in the hold] and was still rising more and more without pumping and bailing with buckets seemed to be unable to prevent it'. The officials became very worried about the condition of the ship when they observed that parts of the sheeting and planking were floating up. The condition of the ship deteriorated even further due to the swell in the harbour. It was when parts of the *slijtkiel* (false keel) and a piece of the keel (measuring 2.5 *voet* long by 10 *duim* wide by 6 *duim* thick) appeared at the surface that the *equipagemeester* of Galle, the skipper of the *Geinwens* and the *scheepsbouwkundige* (shipbuilding engineer) concluded that the ship was irreparable and had to be abandoned: '... therefore we have decided that the ship, after it had been stripped of its rigging and everything else that is still




*Reconstruction of the events leading to the loss of the Barbesteijn*

of value, to demonstrate with so much care that timber can be saved as much as possible.'

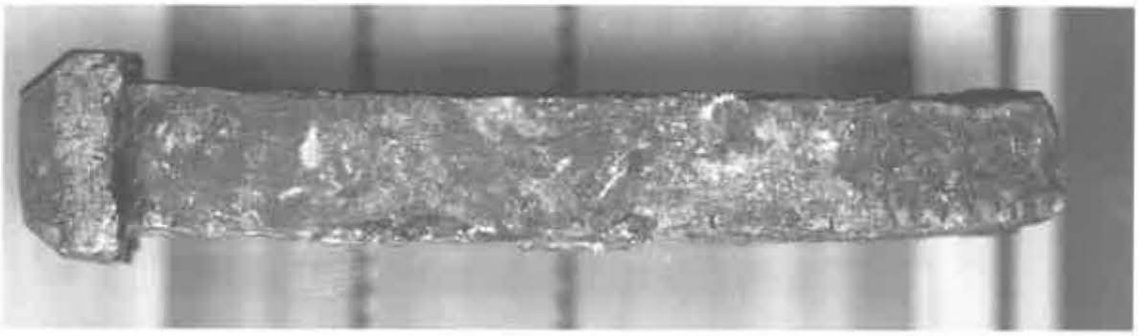
It was decided to use the remnant of the hull as a jetty facility which could be used in times of distress. In order to sink the wreck, the hull was filled with stone ballast. In the margin of this account, found at the SLNA, an indication was given of the place where the ship was sunk: '... to fill the ship with stone ballast to be used in times of distress to be able to moor or *kiel* (*kiel* can mean bringing the ship on its side for cleaning and repairing the lower hull) ships or other vessels the place that is most suitable for this purpose is the spot where at normal times is 13 to 14 *voet* of water.'

A new hypothesis

Based on the above information, a new hypothesis was developed which supported the identification of Site G as the VOC ship *Geinwens*. Several factors favoured the site as that of the *Geinwens*:

1. The ship was stripped before it was sunk (the conclusions of the 1992 and 1993 surveys were that the ship had been comprehensively salvaged);
2. The ship was filled with stone ballast to sink it (Site G is the only site where large quantities of stone ballast were found);
3. The ship was sunk in a depth of 3.5–4 m of water, Site G lies at a depth of 3–7 metres.

Apart from these 'physical' clues, there were more general indications that Site G could be the remains of the *Geinwens*. Although the statement in the report about the wrecking of the *Geinwens* was not very clear about the spot in which the ship was sunk, it does state that the wrecked hull could be used in times of distress. This can be interpreted in two ways: it could mean that the ship was used as a mooring facility in the harbour, and could be used for repairs when other facilities were occupied; the other possibility is that the ship was sunk in a strategic place, where ships which had broken from their anchors could make an emergency stop before running aground or wrecking on the rocks. It is



*Nail from the site*

possible that with the disaster still fresh in their minds, the harbour authorities decided to sink the *Geinwens* in a strategic place in the bay. In that respect Site G, just before the cliffs, seems a logical place.

However, there is also a very strong argument against this hypothesis. During the 1992 and 1993 surveys and excavations, remains of substantial copper alloy sheathing were found. Although Dutch shipbuilders used copper sheathing on parts of the hull (the stem and the stern) from the early 17th century onwards, it was only at the end of the 18th century that they started experimenting with copper sheathing for all of the hull which was underwater. In the 1780s the Dutch Admiralty started to sheathe their ships with copper. They adopted the French method of copper sheathing, so there is a link with the name *Nante* found on one of the sheets. Recently it has been suggested that the VOC had already started sheathing their ships in the Asia trade in the 1740s (Gawronski, 1996: 290).

Strategy for survey and excavation 1997

Another reason for returning to Site G was that new archaeological information had become available in 1995 when the SLSAC found exposed timbers south of the site. It was decided to concentrate the survey and excavation on three areas:

1. Systematic excavation along the edge between ballast stones and sand waves in the south-east corner of the site;
2. Systematic survey of the area east of the baseline between the big boulders; and
3. Systematic survey and possible excavation of the area south of the site where timber was reported.

Baseline and excavation square

A new baseline was established running SW–NE. From the area where, in 1993, an exploratory excavation was conducted to the east and the south, an excavation square of about 10 m was established. A modern concrete mooring is in the centre of the square. The exposed ballast stones in the east extend to the west to a sea bed of sand waves. Here was the best chance of finding surviving timber.

On two occasions the baseline was accidentally disturbed and the grid had to be re-positioned. The final baseline (A–D) measured 14.40 m in length at an angle of 10° east of north, extending a further 11.70 m (D–F) on a bearing of 332°..

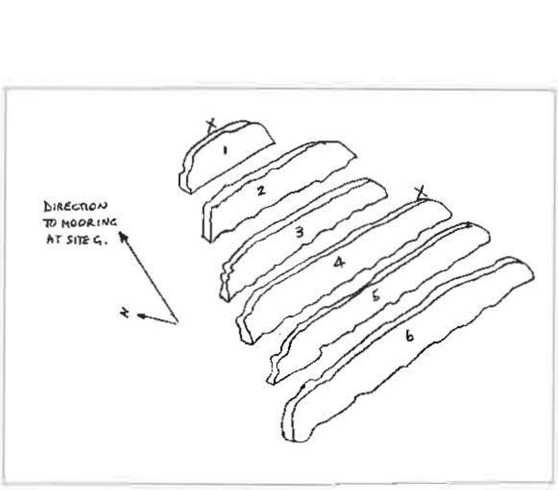
In the first three weeks of the expedition, no water dredge or other excavation tools were available. By hand fanning and the removal of ballast stones within the gridded area, several ships' fastenings and samples of coal, glass and ceramics were found, and one balk of timber was revealed.

Systematic survey

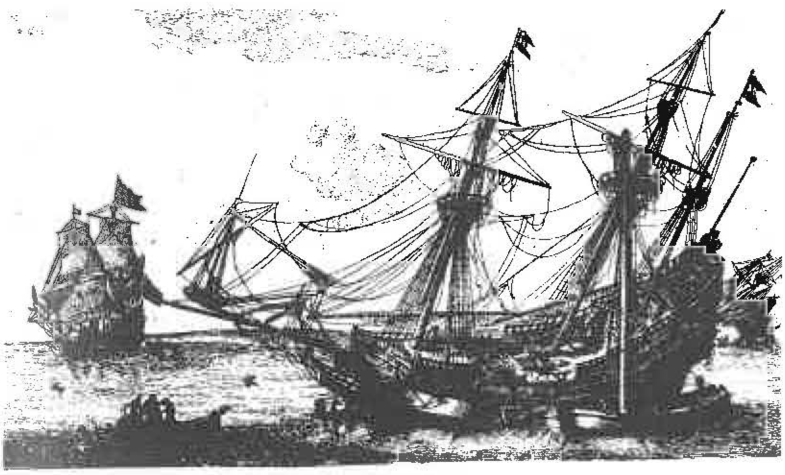
In several dives, a shallow area east of the baseline was surveyed over a distance of about 50 m to the base of the cliff face. Between the boulders, fragments of copper sheeting, ships' nails, coal and concretions were found. North of the site, a large piece of iron concretion was found, but it is uncertain whether this can be related to the site.

Timber

In 1995 a small team from the SLSAC discovered six beams covered with concretion, and planks underneath. They were all heavily waterlogged and subject to attack by wood-borers.




*Plan drawn by the SLSAC of timbers*



*Nooms Kielen. A ship heaved down for maintenance of the bottom. May be the wreck of the Geinwens has been used to facilitate this maintenance activities in Galle Harbour (Reinier Nooms second half 17th century)*

| Beam no. mm | Length mm | Thick-ness mm | Height mm | Distance between beams mm |
|---|---|---|---|---|
| 1 | 762.5 | 50–75 | 254 | 203 |
| 2 | 1525.0 | 50–75 | 254 | 203 |
| 3 | 1677.5 | 50–75 | 254 | 203 |
| 4 | 1830.0 | 50–75 | 254 | 203 |
| 5 | 1830.0 | 50–75 | 254 | 203 |
| 6 | 2135.0 | 50–75 | 254 | 203 |

During the October 1997 expedition, the area south of the site was systematically surveyed. Along the edge of the boulder outcrop, a section of timber 1.25 m in length was found; this timber can be related to the site through the nail hole which corresponds to the nails found on the site. The timbers discovered in 1995, however, were not relocated.

## Conclusion

There are no positive indications that Site G is the *Geinwens*. Four large pieces of coal were recorded on the site. However, these finds, in isolation, do not constitute enough archeological evidence to support the theory that the wreck is in fact a late nineteenth century vessel. The coal may be intrusional material from one of the many modern wrecks in Galle Harbour. The original suspicion that the site is French has been strengthened by the initial analysis of geologist Dr Gunatileke. He indicated that the ballast rocks are certainly not Sri Lankan. From the archives we know the *Geinwens* was loaded with local rock. The type of rock on Site G is, however, very common in France. In order to find the location of the *Geinwens*, further archival research should be undertaken to identify other places in the bay that are appropriate for sinking a ship as a harbour facility.

## Conservation

Conservation procedures and treatments carried out were similar to the previous expeditions, as the predominant material recovered continued to be ceramics (including stoneware and porcelain but mainly earthenware shards). The other types of materials raised were glass (broken bottles), slate, iron concretions, copper alloy (fastenings and sheathing), coal and wood.

Since most of the artefacts were partly covered with calcareous marine growth and hardened sediments, physical cleaning methods, using scalpels and dental tools, were employed. Removal of these deposits allows salts to be released from the artefacts at an even rate during soaking, prevents the quick neutralisation of acids when such treatments are deemed necessary and optimises treatment times. An example of an iron concretion from Site G was X-rayed at a local hospital to identify the content and ascertain if any residual metal remained. The latter was confirmed with a magnet. This and other iron concretions were stored in a solution of sodium carbonate (5% w/w).

### Copper alloys

Artefacts made of this material were physically cleaned, using dental tools, to remove sediment and shell, then rinsed in fresh water and allowed to dry. No bronze disease developed during the period of the expedition. The treatment recommended is citric acid–thiourea to remove corrosion products, followed by neutralisation and soaking in sodium sesqui-carbonate solution.

### Ceramics, glass and slate

The pottery shards, glass and a single slate artefact were stored in fresh water. Marine encrustation was removed by physical methods as necessary. All required extended soaking in fresh water to remove salt.

### Coal

All lumps of coal were rinsed in fresh water to remove salts and allowed to dry. A large piece of coal, recovered at Site G, was physically cleaned and treated with citric acid (5%) to remove the final traces of calcareous deposits.

**Site F—The *Hercules* (1661)**

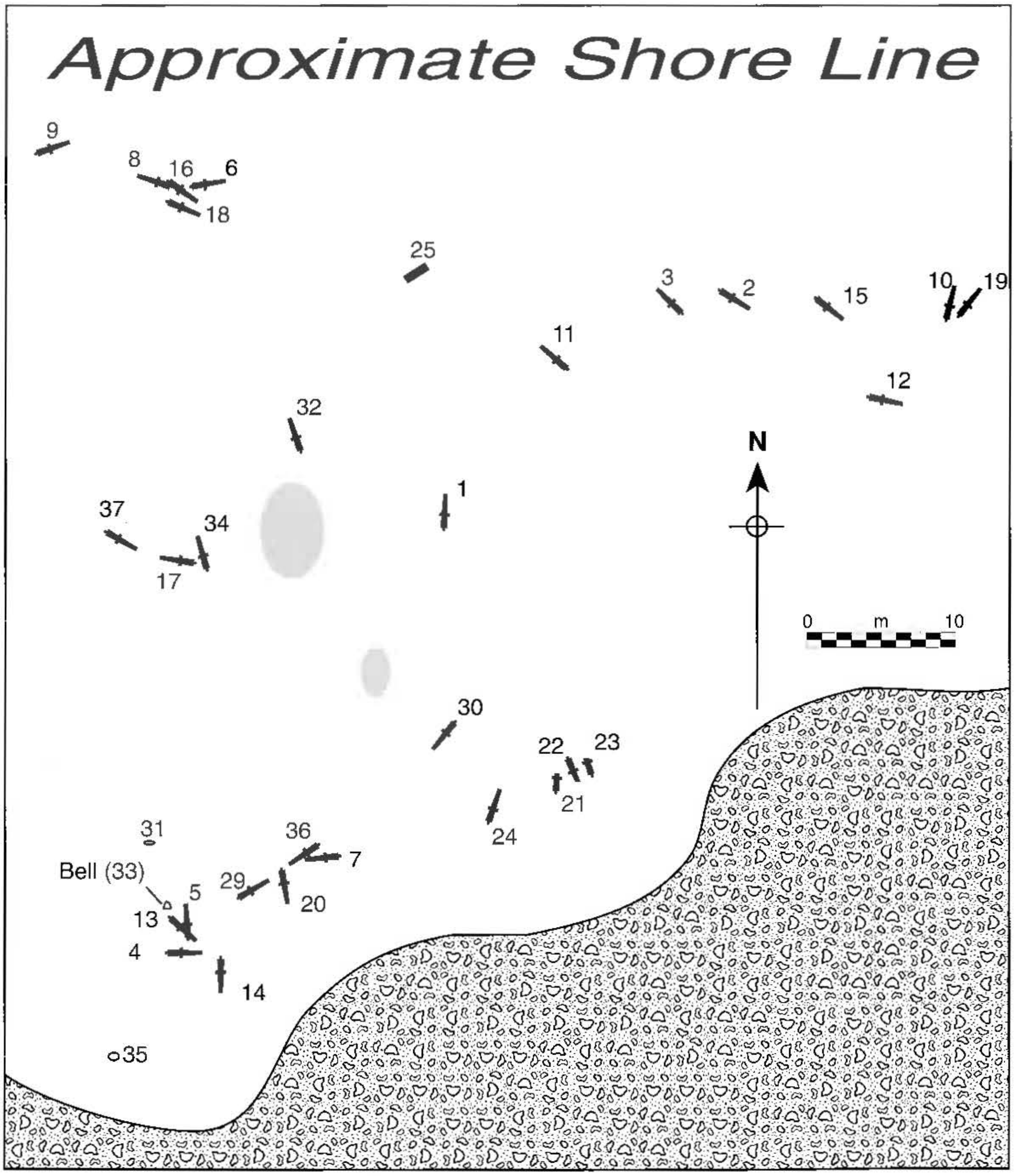
**Site description**

The site lies diagonally across the east–west seaward-facing slope that rises up to form the rock seawall of Gibbet Island. The site is characterised by large boulders interspersed with coarse grain sand. Scattered amongst the boulders are approximately thirty large, concreted cast-iron cannon. During the 1997 expedition, the site was given a cursory inspection but poor visibility and rough sea states were not conducive to further work. A full description and summary of work to date may be found in the 1993 excavation report.

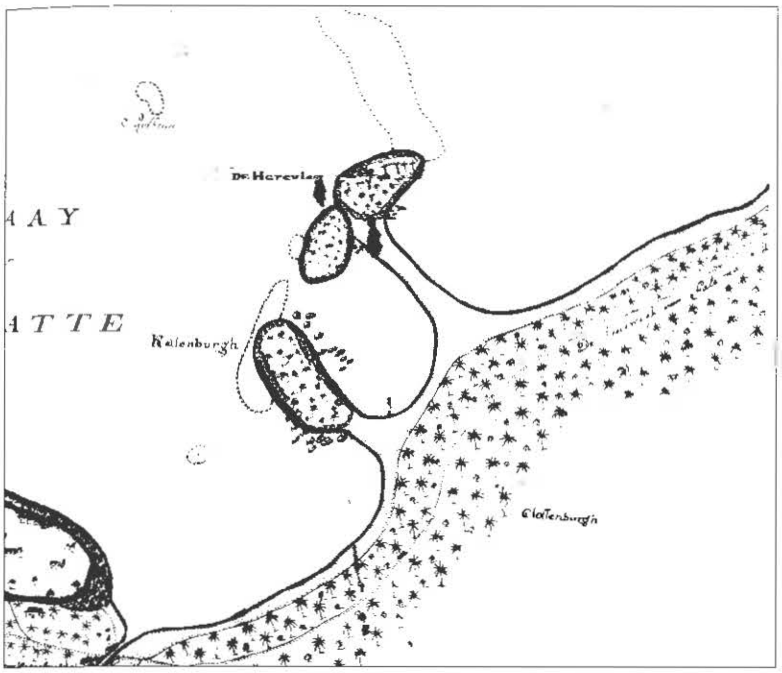
**Archaeology and history**

The *Hercules* (1661) and *Dolfijn* (1663): Examples of inter-Asian trade and shipping

At least two other ships wrecked in Galle Harbour, the *Hercules* (1661) and the *Dolfijn* (1663), are representative of the inter-Asia trade. The *Hercules* was wrecked as she departed from Galle with a cargo for Batavia. The *Dolfijn* was lost within sight of the harbour, coming from Surat. Both vessels belonged to the class of yachts especially designed for the Asian trade. In its first fifty years of operation, the VOC developed several kinds of ships suitable for the different trade areas in Asia. In the Resolutions of the Directors of the VOC in the Netherlands, one can trace the development of shipping organisation during the 17th century. Originally, the Dutch sent large ships to the Indies to collect cargo from all around Asia before returning to Europe. This had many disadvantages, and was soon to be replaced by a system whereby




*Hercules site plan*




*Detail of map showing Hercules site*

the VOC operated from a permanent headquarters and central hub in Asia.

In 1619 the Dutch captured the city Jakarta on Java, renaming it Batavia, and it was from here that shipping in Asia was organises. Large ships were sent from Europe to Batavia to collect the cargo brought in by smaller ships from all parts of Asia. For many years, the yachts which coursed these routes proved also to be suitable for the trade to India and Sri Lanka. In 1611 a commission appointed by the Directors of the VOC recommended using a smaller, fast-sailing ship with three decks, giving enough space both to store supplies for the crew, and for cargo. After this advice, a ship measuring 104 *voet* in length, 26 *voet* in width, and 13 1/2 *voet* in depth was brought into use (Parthesius, 1995: 69) (an Amsterdam *voet* is 0.283 m. and contains 11 *duim* of 25.7 mm).

The *Hercules* was such a yacht—built for the inter-Asia trade. The ship was constructed in 1655 in a shipyard in Zaandam (a shipbuilding centre north of Amsterdam). Built at a cost of 25,150 guilders the ship had the following specifications: length 140 *voet;* width 33 *voet;* draught 14 1/2 *voet;* and the space between the first and the second deck 7 1/2 *voet* (ARA VOC 235, 9 August 1655). The yachts sailing to India had become bigger and more heavily armed following their use in the blockade of Goa (the Portuguese headquarters in Asia) in 1655.

The *Hercules* departed for Asia in 1655, and operated there until she was wrecked in 1661 on the rocks near Closenburg, on the north side of Galle Bay.

In the early morning of 22 May 1661, a small fleet of four ships was ready to sail to Batavia. Two officials of the fleet were persuaded by the fine weather to take the ships out of harbour before any adverse change. There are several reefs in the area which lie hidden just below the surface, inviting disaster for ships entering or leaving the harbour without a pilot at the helm. After the flute *Elburg* and the yacht *Tholen* were guided out of the bay, the pilot returned and made preparations to take the yachts *Hercules* and *Angelier* out of the bay together. An eye-witness aboard the *Angelier* gave an account of what went wrong after the ships weighed anchor:

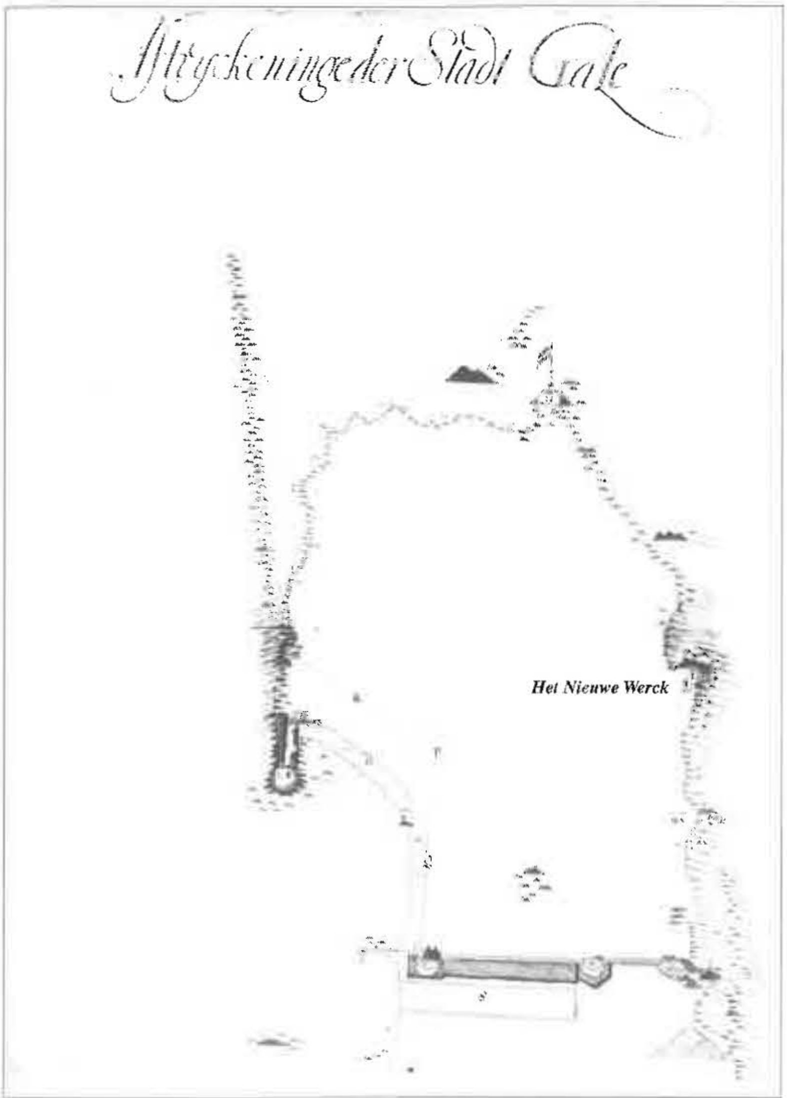
> When the crew of the *Angelier* had weighed anchor and were busy pulling up the sails, quite suddenly a strong cross-wind struck the ship. We managed to fasten the sails again and to throw the anchor. On the *Hercules* however, which was half a pistol shot from us, things went wrong. I saw that the anchor rope was broken. This seemed strange to me since this rope wasn't bad and no other ship in the bay at that moment had the same problem. Still they tried to throw the second anchor, but in this case the end of the rope wasn't secured to the mast so they lost the second anchor too. Without anchors the ship was now a playing ball of the elements. The bow of the ship turned in the direction of the land and was breaking to pieces on the cliffs a few moments later (ARA VOC: 1238-9 folio 1137-40).

After the disaster, the pilot was interrogated. He explained that the cross-wind struck when they were in the process of weighing anchor; in the ensuing panic, the anchor rope stuck between the ship and the rudder, with a catastrophic result. The whole cargo was lost: 1700 packets of fine cinnamon, and a cargo of Canarase rice.

Apart from the type of ships used for the inter-Asia trade, there is also the question of the equipment of the ships. The VOC had strict regulations concerning the equipment of ships sailing between Europe and Asia. Information about the regulations within Asia, is not available to date. An interesting issue is the arming of the ships. On the wreck site of the *Hercules*, 31 iron guns were found: this was many more than would be expected for a ship of that size. However, a list of ships operating in Sri Lanka in 1657, found in the Dutch records in Colombo, also shows a picture of heavily armed ships (SLNA 1/9 Council Minutes 1657–63, 29 Nov 1657). It is clear that the VOC followed a flexible policy on ship armaments, and ships were more heavily armed if they sailed to areas where enemies were active (Stapel, 1927: 507; Parthesius, 1993: 24).

The maintenance of the fleet and the crew was one of the biggest concerns of the VOC Directors in the Netherlands and Asia. In the first years of the 17th century, most of the ships made the round trip to Asia without proper maintenance in Asia. With the establishment of the VOC headquarters in Batavia, a permanent repair facility came into operation. Every ship sailing to Batavia carried large quantities of spare parts and maintenance products such as masts, sails, nails and tar. In order to maximise efficient use of the ships the Directors in Batavia introduced a 'quality registration system'. Every year the ships were inspected. Ships in good condition were allowed to make the trip to Europe; moderate ships were not fit any more for such a long voyage but could serve in the China–Japan and India–Arabia routes. Inferior ships were used only for short journeys to the Spice Islands. Despite the better maintenance and the monitoring system, ships were often wrecked or abandoned because of the bad condition of the ship and crew. The history of the yacht *Dolfijn* is an example of this.

This vessel sailed from Sualijs (Surat) for Batavia on 29 April 1663, after loading packets of yam and mail. Shortly after departure, the crew found that the ship was leaking badly; even with two pumps they were not able to keep her dry. So they returned to port and examined the ship. After sending the skipper, the high boatswain and the constable's mate below, the leak was found in the powder magazine on the port side. The powder was unloaded and the carpenter was able to repair the leak. On 30 April the *Dolfijn* sailed for the second time. While passing 'het Hoogelant van St. Jan' the ship was strained by heavy seas. Again the crew had to pump day and night to keep her dry. On 3 May the skipper discussed their difficult situation in the *scheepsraad* (the ship's council of officers). They arrived at a VOC post along the coast of India and asked a merchant there called Zandtvliet for assistance. They asked for 20–25 locals to join the ship to man the pumps in case of emergency. This request was unsuccessful because the locals asked too high a price: one *pagood* (local currency) per month, free water, firewood and rice, plus a galley and six months' pay in advance. So the vessel left without assistance but with 32 packets of *amphiaen* for Coetegin [Cochin]. The *Dolfijn* arrived there on 10 May, '*lek maar behouden*' (leaking but safe). Once again a request for assistance was turned down. The ship was told to sail on to Galle. It was on this part of the voyage that things went really wrong. On 14 May the ship was at 6' 10" North in bad weather when the leak became worse. The skipper decided to anchor in 13 fathoms of water in order not to miss the Bay of Galle. To keep the ship dry, a fourth and a fifth pump had to be installed. The crew was so exhausted after constant pumping that they were not able to lift the anchor. After cutting the anchor rope, the *Dolfijn* sailed along the coast to the Bay of Galle. In the entrance to the bay, the ship anchored and fired several guns as distress signals. The situation became untenable, since even five pumps were not enough to keep the ship afloat and buckets were also needed. The only sensible thing to do was to sail the ship into the bay as quickly as possible in order to save the crew, money and cargo. Again the problem was to lift the anchor because the crew were either fully occupied with pumping or were completely exhausted. Another problem arose when the pilot came on board. He explained that it was impossible to enter the bay because the ship was lying directly in front of a shallow reef and the wind was not favourable. Aware of the seriousness of the situation, the VOC sent assistance from the shore, but by the evening there was no option than to abandon ship since the galleries at the side of the cabin were already striking the water.




*Manuscript map of Galle made by Adriean de Leeuw, with suggestions of improvements to the defence works of Rijckloff van Goens and Adriean van der Meijden, 10 mei 1659. From this map we can identify the location of 'het nieuwe puntje' in the report about the wrecking of the Dolfijn*

An eye-witness account of the disaster was found in the dairy of Adriaan van der Meijden, who was a high-ranking VOC official in Galle at that time (SLNA, Dutch Records: 1/ 2712).

> Shortly after the afternoon a ship came sailing in the direction of the bay. Because it was firing its guns constantly we assumed it was in distress. Originally we thought that it was the *Achilles* sailing from Persia. We gave the pilot Bastiaen the order to go to the ship as fast as possible because the wind was strong and showery. After several attempts, the skipper and former pilot of this bay, Daniel Harthouwer, succeeded on getting aboard. Eventually the costly ship the *Dolfijn* was pitifully wrecked in the dark evening ... The *thonij* brought the undermerchant Meijndert Janssen ashore. He went back on board after handing over the letters from Suratte ... According to the letters the *Dolfijn* carried a rich cargo. To protect the cargo in expectation of salvage the guards on the *klip bij d' vlaggespil en aen't nieuwe puntje* ...received the order to stop ships nearing the place of the wreck.

### Location of the *Dolfijn*

Based on the earlier information, we know that the *Dolfijn* sank in front of the harbour. This can mean two things: the ship lies in front of the harbour but, according to the pilot, behind a reef or shallow place; or the ship lies in front of the *valse baai* (false bay) at the west side of the fort. We also know that the ship must lie in a depth of about 13–20 m. The day after it sank, only the upper-sides of the masts could be seen above the water.

Another clue to the ship's location comes from the guards on *puntje van de vlaggemast* (now The Point of Galle) and *het nieuwe puntje* (the New Point) to prevent people from going to the wreck. This *nieuwe puntje* is a bit confusing because there are several places with this name. Later, in the 18th century, there was a place near the Point *Akersloot* on the east side of the city. From some maps and the *Generale Missive* of the VOC, we know that at the end of 1662 constructions were going on at the east side of the city under the name of '*Nieuw werck*'. This means that '*het nieuwe puntje*' must be Aeolus (Valentijn, 1726; Wagenaar, 1994: 69).

*Inspecting one of the Hercules guns*

Based on these records the location of the wreck will be somewhere to the south-east of Point of Galle. After earlier attempts in 1993 to survey the area SE of the city, side scan sonar and magnetometer surveys were carried out in 1996 and 1997 resulting in the discovery of a number of interesting targets. A decision was made to postpone visiting the site to avoid the danger of looting.

### Conservation

No conservation work was undertaken in the 1996 or 1997 seasons pending the completion of the Galle Conservation Laboratory. However, a full conservation management report for this site was published by Carpenter and Richards (1993).

### Site L—the *Avondster* (1659): An example of local trade and shipping

### Site description

The wreck at Site L lies in the north-western end of Galle Harbour, about 50–100 m south of the rock shore-line, opposite the Galle market.

The partially buried wreck lies on a gently shelving sea bed composed of sand and finer sediment, covered with organic detritus. The sediment affected visibility significantly when disturbed by water movement. The water depth over the site ranged from 2–4 m. There are no reefs in close proximity.

During the 1996 expedition, following heavy rain, a noticeable layer of fresh water was present on the sea surface. During the monsoon seasons, fresh water would flow directly into the harbour from drains in close proximity to the site. The decreased concentrations of dissolved salts due to the influx of fresh water produced a low salinity reading in the harbour. The presence of fresh water will directly affect biological activity and the degradative processes occurring on site. In addition, based on archaeological evidence, the vessel remains at Site L are believed to date from the mid-17th century. At that time, two rivers flowed directly into the Bay of Galle. Such a large source of fresh water would have decreased the overall degradation rate on the site during this time period. It is important to note that the rivers, which were near the wreck site, no longer flow in this area.

There was no obvious evidence of human disturbance on this site. However, because the site is readily accessible from the sea and the land, it is assumed that heavy salvaging of exposed artefacts may have occurred over the years. The close proximity of the wreck to the town of Galle has resulted in contamination of the site with modern materials, such as paper, newsprint, clothing fragments, animal remains and other rubbish.

The remains of the vessel lie parallel to the shore-line in a NE–SW orientation at a depth of approximately 3m–4 m, covering an area about 40 m long by 10 m wide. The bow lies towards the SW, and the stern in a NE direction. The wreck consists of an outline of timber frames and planking averaging about 500 mm above the sea bed. The vessel's timbers are exposed at the bow end, and at about mid-site the perimeter of the vessel becomes buried in sand. After a short distance the timbers are uncovered again for a few metres, then become completely buried until a relatively extensive section of the stern is reached. The stern protrudes approximately 2 m–2.5 m above the sediment. The centre section of the site is almost entirely covered with sand. In two places along the inner port side, a deck support timber protrudes from the central sand mound. A large (5 m by 1.5 m) assemblage of bricks (*overijselsteen*), cemented together, lay partly exposed in the centre of the site. Lead sheet protrudes from the sand nearby and was, following excavation, proven to be associated with the brick mass. On the shoreward side of the site, near the bow, a large wrought iron anchor shank, on the remains of its wooden stock (which has totally disintegrated since it was first sighted in 1993), rises from the sand and terminates in a complete anchor ring, 3 m beneath the water surface. There is only a light covering of sand around a matrix of concretions inside the bow region. Iron concretions extend from the starboard side of the bow region and continue to where the timbers first become buried. Four concreted iron cannon were located, all positioned on the starboard side of the vessel. Very difficult to work effectively, this site in the 1997 survey was subject to low visibility, strong surge and undertow due to its close proximity (approx. 50 m) to the shore (sand beach backed by a rock wall). Although prominent features such as the shank of the iron anchor, iron cannon and stern timbers are still visible, it appeared that some redistribution of sand had taken place since the last inspection in 1996.

*Avondster wreck site with work boat on site*

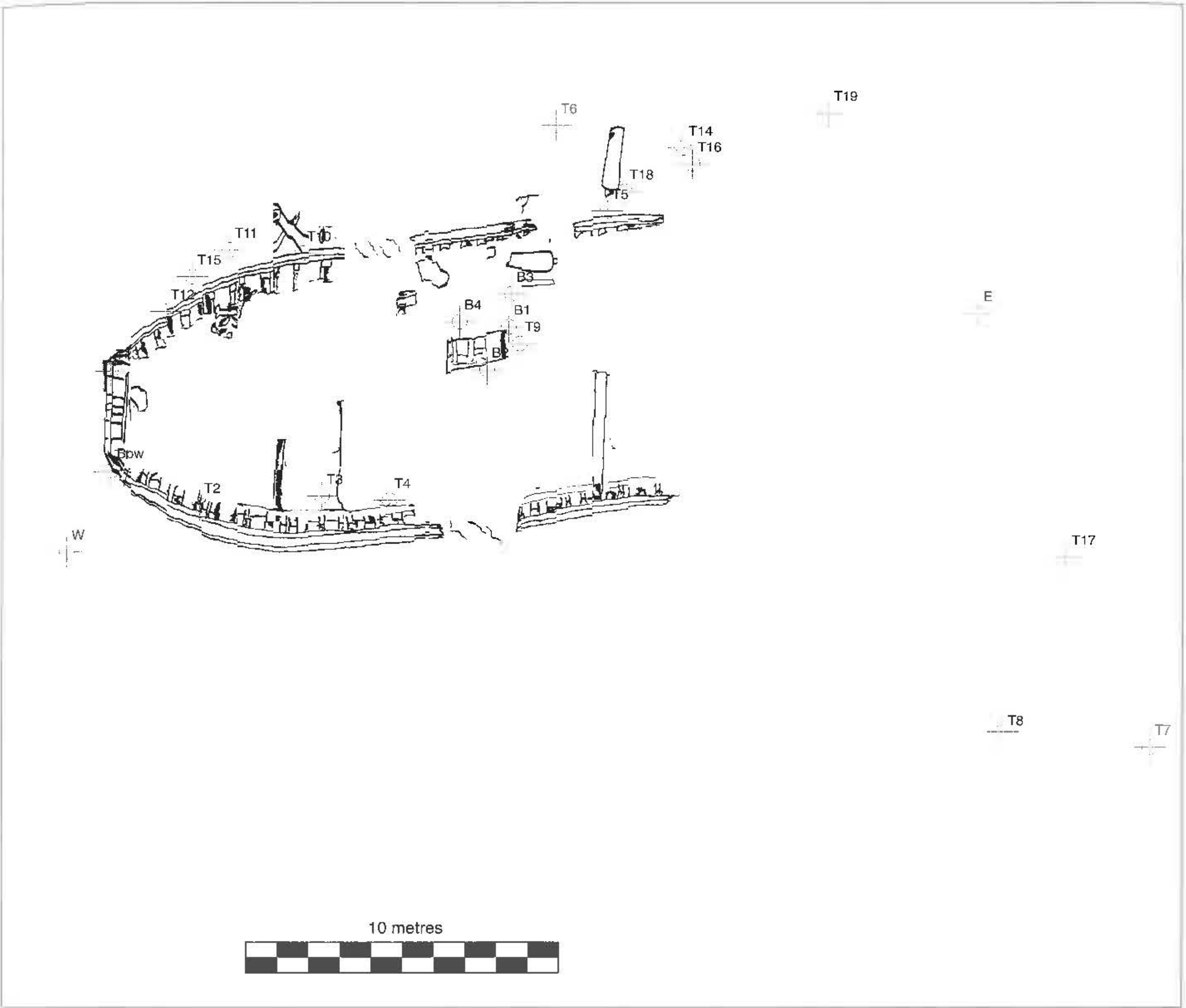
**Archaeology and history**

In the 17th century, because Colombo lacked a suitable natural harbour, Galle acted as an important port for transhipment. An extensive network of local trade and shipping existed from earlier times between the coasts of Malabar, Coromandel, Bengal and Sri Lanka. The inter-regional, or coastal, trade used relatively small vessels such as Sri Lankan-built *dhonis*, European sloops, or old worn-out European yachts such as the *Avondster*.

The *Avondster* was wrecked on 23 June 1659. She was anchored near the Black Fort but despite fine weather, slipped her anchor during the night and hit the coast north-east of the anchorage. Soon after grounding, the old ship broke in two and was submerged in the soft sand. The circumstances of the wrecking were unclear. An eye-witness account, found in the Dutch records of Colombo, tells how a sailor on deck discovered the vessel drifting and tried to wake the skipper. The skipper was slow in making his appearance, and by the time he ordered the warp anchor to be thrown out, it was too late. After the disaster, the skipper and the first mate were arrested, convicted and ordered to pay the damage. The *Avondster* had been loading cargo for a trip to Negapatnam in India. After the ship was lost, there were no other VOC vessels available to transport the cargo remaining on-shore, which included areca nuts. The VOC officials decided that the *burghers* (free citizens) should be allowed to buy the cargo, but only on condition that it was transported to the original destination and sold for the original price (SLNA1/9 folio 142).

The loss of the *Avondster*

> ...is to our great distress on the 2 July at night the old yacht the *Avondster* in Gallons Bay, after slipping her anchor rope, in silence slipped her mooring and because of bad supervision was wrecked. This happened because the mate Bartel Schagh van Dansish, who was called to his watch, didn't pay enough attention and went below. In the meantime the boatswain's mate Evert Albers and the steward Dirc Willemsz wrongly, expecting the evil indeed let the small watch looking out, at the end the




*Avondster wreck site plan with site sketch map superimposed on accurate control point survey*

schipper Arent Danielse Lem, who was also omitted a quarter of a hour before he ordered to drop the anchor; he assumed he could bring the yacht in deeper water with a kedge. But because he was waiting the yacht struck ground and broke immediately in front of the garden of Marcus Lasseres, and the out coming river on the side of the mountain (ARA.VOC 1129 folio 162).

### Survey and test excavation

Some limited exploratory excavation work was carried out to determine the potential of the site and to assist with identification. Investigations suggest that the vessel has broken into two parts but is well preserved, and that the site is artefact-rich. Conservation data was gathered to measure corrosion potential and the degradation of the timber.

The archaeological work concentrated on delineating the site. The first phase was a trilateration survey to determine the extent of the site. Survey points were placed around the site on key features, and inter-point measurements were made on a matrix. Thirty-one points were selected on the site, with measurements made between each of the points (1–2, 1–3, 1–4, etc.; 2–3, 2–4, etc.; 3–4, 3–5, etc.; 17–18, 17–19, etc.; 30–31). The measurements were then run through the Web for Windows programme, and adjustments made. The resulting plot of the points and co-ordinates is shown above.

#### Test excavation

A test excavation was conducted around what is thought to be the stove of the galley. The stove is relatively intact,with a hearth and some of the walls surviving. Unfortunately, because of the poor visibility on the site during the survey, it was extremely difficult to record.

Efficient dredging was hindered by the heavy pollution of the sea bed with floating plastic and other general debris, and by a sea bed of fine sand which quickly refilled the dredged holes. Dredging around the galley revealed lead all around the bricks. The wall at the south side of the floor descends below the floor for at least another metre. East of the galley, other broken parts of a wall were found. The brick floor comprises one layer of standing brick. Underneath, a hard mortar was found (sample taken). Usually on VOC ships of that period the space between the bricks and the lead or copper sheathing on the floor was filled with a mixture of sand and salt to insulate the hearth to the wooden deck planking. At the edges of the floor there is a thin layer of lead. At several spots, traces of wooden construction were found. The dimensions are roughly 1.90 m (N–S) 1.50 m (W–E) and a diameter of 1.75 m. The middle of the floor contains traces of the fireplace; around this are iron concretions of possible equipment or fastenings.

Remains of the walls are scattered over a large area. One piece is still in place: about 1.650 m–1.800 m long and 400 mm–550 mm wide, with a height on the east side of 550 mm. There are several concretions stuck both to the floor and the wall, which may be remains of fittings for cooking-pots.

Excavation started from the NE to the S. On the east side, several pieces of brickwork and the wooden construction of the collapsed wall, together with torn-off lead sheets, indicate the collapsing of the wall. The SE corner of the wall slopes down into the sea bed; the foot of the wall is 1.42 m from the top of the standing wall. The construction of the wall in this corner is still obscure. The wall seems to go deeper than the level of the brick floor. From the top of the wall along the outside measures 1470 mm, while the distance from the top to the floor at the inside is 950 mm.

The excavation along the south side of the galley revealed traces of a collapsed wall in the SW corner. At this point a deck beam was found, coming from underneath the galley and running S–N. The beam is 350 mm thick. Following the beam northwards, a broken knee was found at the ship's wall, and next to it, an open barrel with a diameter of 650 mm. Survey around the barrel revealed a copper object and a musket ball.

On the west side, the edge of the lead going under the floor was found 230 mm from the top of the floor. Underneath, softwood planking was found. The lead flaps of which the box is made are 410 mm wide. At the side, a complete barrel was found and left *in situ*.

The north side is scattered with concretions; there are signs of a wooden wall construction 20 mm thick. Next to the galley, a brick was found with clear marks of an iron fitting, possibly a hinge for a door or hatch.

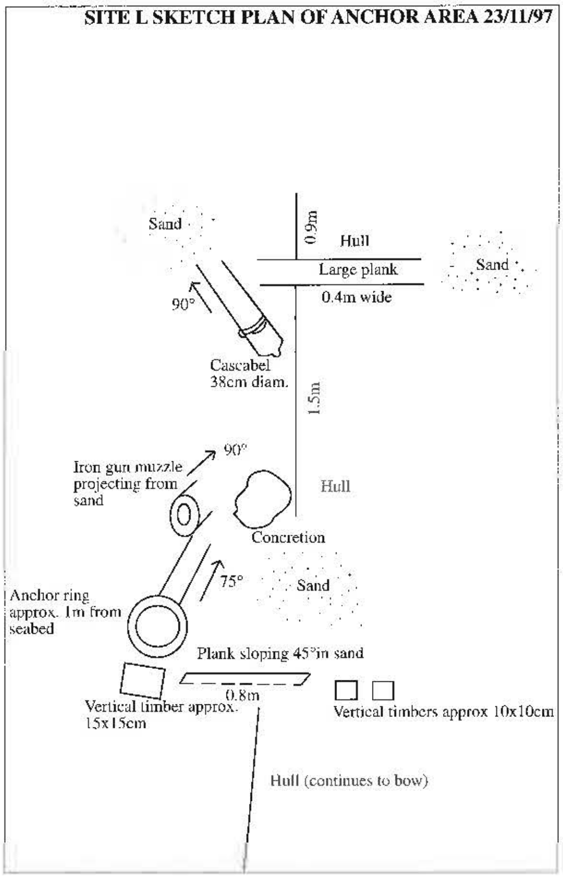
Historical notes on galleys

The test excavation raised questions about the location, size, fittings and construction of the galley details of which can be gleaned from historical sources.

*Location*

In the 17$^{th}$-century descriptions and on some plans of VOC-ships (see fig ????), the galley or *kombus* was located on the orlop deck at one side of the main mast; at the other side was a similar room, the *bottelarij*, where the steward prepared the drinks handed out to the crew (Witsen, 1671: 59, 91; Van Yk, 1696:136). Another possible location was under the *bak* (forecastle) (Witsen, 1671: 268). On small ships, where there was not enough space for a separate room, the galley was not much more than a wooden box filled with sand; rings at the sides were used to fix the galley wherever convenient (Van Yk, 1696: 304; Vlierman, 1993). The galley of a 'man-of-war' was located in the hold (Witsen, 1671: 59, 91, 268).

The galley is located on the orlop at the port side of the main mast. Behind the galley, a hatch leads to the food supplies under the deck.




*Avondster detail sketch plan*

*Beardman jug from site*

The galley was small in relation to the number of seamen for which it catered, generally not much larger than 2.5 m square. On the bigger vessels sailing between Europe and Asia, it was common to have a crew of about 300 people; on the routes within Asia the crew might be half this number. The dimensions of the galley for a ship of 134 *voet* were 6 *voet* by 4 *voet* (1.70 m by 1.15 m); larger galleys could be 7 voet (1.95 m) square.

*Construction*

The galley was fitted in a wooden construction, described by Witsen as follows: standing posts 3.5 *duim* by 3 *duim* (80 mm by 75 mm); the planks of the walls 1.5 *duim* (37 mm) thick; the floor under the bricks comprised of planks 3 *duim* (75 mm) thick and 15 *duim* (300 mm) wide (Witsen 1671: 91).

The wooden construction was sheathed with metal on the inside for fire protection. Copper was generally used, but there are references to tin and even lead being used as sheathing. Journals from early 17th-century shopkeepers indicate that two different thicknesses of copper were used, probably thinner for the walls and thicker for the floors. The same journals contain an account for the sheathing of a galley with old lead (ARA VOC, 14854 folio 156).

The floors and parts of the walls of the galley were laid with bricks. There are a number of references to the amount of bricks and mortar used. Witsen describes the quantities needed for a galley measuring 7 *voet* square: 1000 *leidse steentjes* (Leiden bricks) and 1 *hoed* of lime for every 3 000 bricks (Witsen, 1671: 91). In 1610, the building of the yacht *Brack* required 800 *welgeboren* bricks, together with 4 *tonnetjes* lime and 12 *matjes* sand. For the *Bantam*, 1500 *goudse* (Gouda) bricks, 1 *hout* lime and 27 *mandjes* sand were used (ARA VOC, 14854).

As an extra fireproof layer, sand or salt or both were laid between the sheathing on the floor and the bricks. Many occurrences are known of burning through the galley floor; one incident is of particular interest, as an examination showed that the galley had burned down because there was no salt mixed with or put under the sand (BTLV-NI-1875).

*Iron fittings in the galley*

The concretions found on and around the floor of the galley are possibly the remains of iron fittings for holding pots and pans. A description of this construction was given by Van Yk, who speaks about an *ezel* (donkey) placed 4 *voet* 5 *duim* from the rear end of the galley; two iron bars were constructed 7 *duim* and 21 *duim* respectively from the wall, and 1 foot above the floor. This description may be compared with prints of 17th-century kitchens

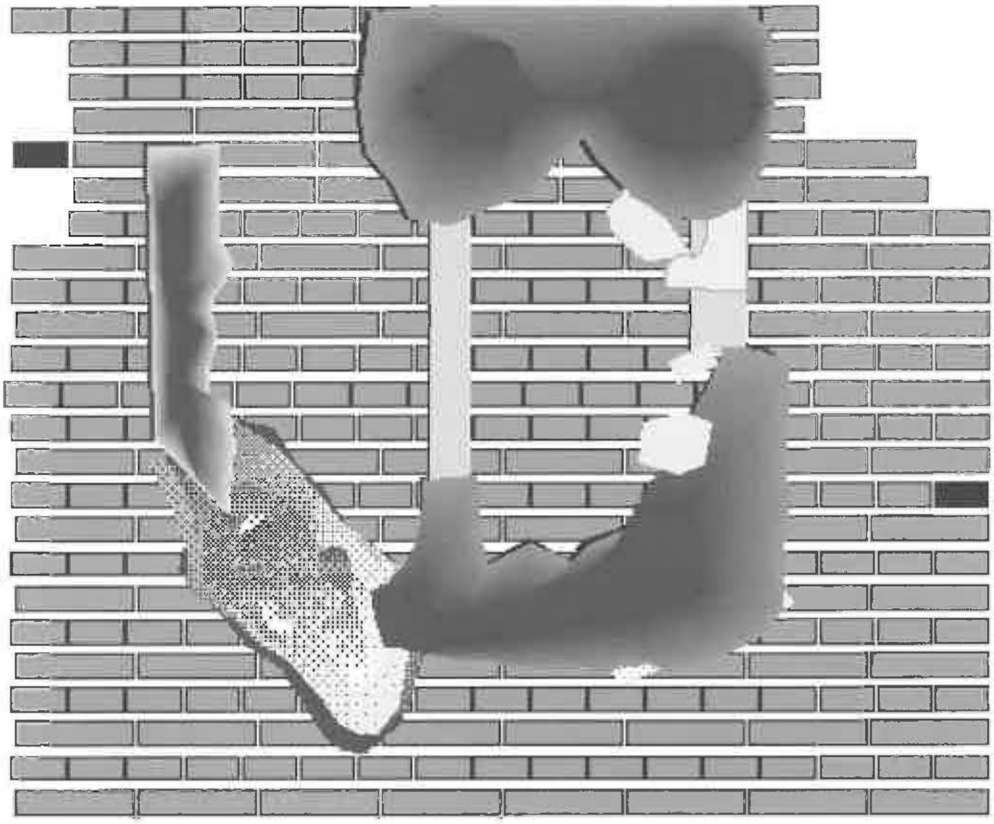
The pot was housed in the kitchen hanging above the fire on a hinge. It is not certain if this system was in use on board ships. In the galley of the *Vasa (1628)*, the pot was hung on a bar above the fire (Landström, 1980: 138). Gridirons were used as pan stands or to grill on directly.

Ship's construction

A small section of the north side of the ship was dredged east of point 10. Double outside planking, frame heads, ceiling planking, a knee and a horizontal construction which may be part of a gun port were exposed. Next to the knee at point 10, remains of two beardman jugs were found. No further survey and recording of the ships' construction has been done.

**Conservation**

The extensive conservation management report for Site L is reproduced in Appendix 1. In 1996 a little more of the vessel appeared to uncovered. In particular, a large part of the stern was exposed which had not previously been located, although it may have been missed in the 1993 survey. A significant change had occurred to the wooden



*Plan of base of oven on site*

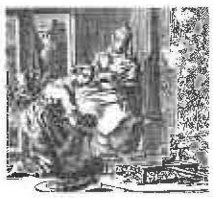
stock of an anchor since it had been observed in 1993 (Carpenter & Richards, 1993). During the 1993 survey, approximately one-half of the stock was exposed, and its extent of preservation suggested it had only been recently exposed. In the 1996 survey, the surviving portion had lost more than half its length, and, in 1997, the wooden stock had totally deteriorated. Site L is a chemically and physically dynamic site. There are many synergistic and opposing chemical and microbiological reactions occurring on the site, which makes predicting the overall effect of this site on the rate of degradation of artefact material difficult. However, in general, the buried hull remains have been protected by the sediment and are in sound condition after approximately 300 years of immersion in this marine environment. Alternatively, the exposed sections of the wreck are slowly being destroyed. The causes are mainly physical mechanisms and, to a lesser extent, biodeterioration that are contributing to the *in-situ* degradation of this wooden vessel and its associated artefacts. Refer to Appendix 1.

Wood samples

Samples of the timber were taken for dendrochronological research. The exposed timber was in most cases heavily waterlogged and had been subject to attack by wood-borers. Samples were taken with a handsaw from the planking at point T2, and from the frames at points T10 and T12.

This research was done in the Netherlands by Dr E. Jansma, with the assistance of Thijs Maarleveld (ROB, *Afdeling Archeologie Onderwater*). Only the sample GHL/96/wood/5 was potentially suitable. However, it turned out to be too small for a matching with the Dutch, West German and English curves.

| Reg. No. | No. | Mat. | DESCRIPTION | DATE | LOCATION |
|---|---|---|---|---|---|
| GHL/96/wood/1 | 1 | 61 | In-layer-outplank | 23/3/96 | T2 |
| GHL/96/wood/2 | 1 | 61 | In-layer-outplank | 23/3/96 | T2 |
| GHL/96/wood/3 | 1 | 61 | Frame | 23/3/96 | T10 |
| GHL/96/wood/4 | 1 | 61 | Frame | 23/3/96 | T12 |
| GHL/96/wood/5 | 1 | 61 | Frame | 23/3/96 | T12 |



*Illustrations from Luiken's Het Menselyk Bedryft showing ovens and cooking arrangements*

**Sites P & T—Stone anchors near Black Fort**

**Site description**

Background

During the 1996 expedition, a side-scan sonar survey led to the discovery of the stone anchor site. A circular search to investigate a side-scan anomaly resulted in the discovery of one large Arab-Indian stone anchor and a broken portion from a smaller anchor of the same type. The anchors are likely to be pre-European and could date from a very early period. The larger anchor was initially recorded as *c.* 3.5 m long, the broken anchor approximately 1.5 m. Both were located close to the Black Fort, in the area of Kamba Bandina Gala, a traditional mooring-site for vessels lightering cargo to and from vessels to Galle. The stone surfaces appeared undamaged and were only lightly colonised by algal forms and sessile marine invertebrates. In the same general area is a site known to have ceramics from a wide geographical and temporal range. This could possibly be associated with the mooring of vessels and the stone anchors. Petrographic analysis would be particularly important, in this case, to determine whether or not the stone from which the anchors were made came from the Galle area. If the stone was found to be of local origin, then it is likely that the anchors had been constructed for mooring purposes in the harbour. If the stone came from elsewhere, then they would be more likely to be anchors off a ship.

The anchors, when discovered, lay flat and half-buried on a sand sea bed that was covered with a layer of finer silt and organic material. Sediment samples were collected for analysis.

*The large stone anchor being brought ashore at the wharf*

During the 1997 season it was planned for these stone anchors to be raised to determine if there were any inscriptions; also, for petroglyphic studies to ascertain the origin of the stone; and for public exhibition. Following conservation, the anchors will make an impressive display for the Maritime Museum in the Galle Fort.

Site location

To relocate Site P traditional methods incorporating visual and photographic transits were employed as the differential GPS was unavailable. The photographic transits used were those taken during the 1996 expedition (Negative No. MA 4807). The relocation of the site was hindered by poor underwater visibility, which ranged between 0 m and 1.5 m at best. The visibility improved the week prior to full moon, indicating the poor visibility was the result of tidal influences and subsequent sediment movement.

This area was only given a cursory inspection following the discovery of two stone anchors at the end of the 1993 season. The sea bed is comprised of sand and finer sediments interspersed with broken ceramics, stone fragments, iron concretions, firebox slag, bones, coal and modern rubbish, etc. Although the area is subject to surge, the sea bed is generally level except where the presence of large objects, such as stone anchors, have resulted in scour or build-up of sand on one face. Finer sediments tend to overlie coarser sand, which holds the bulk of the objects mentioned. See comments on stone anchors and associated wood.

Refer to the description of Site J in Carpenter & Richards (1993) for a broader interpretation of the underwater environment of Site P, which is encompassed by the J area.

**Archaeology and history**

Underwater search methodology

After fixing the apparent position using transits, diver-based search methods were employed to relocate existing anchors and find new artefacts. Circular jackstay searches were used to ensure maximum coverage in low visibility. Swim-line snag searches were also used by divers to locate objects.

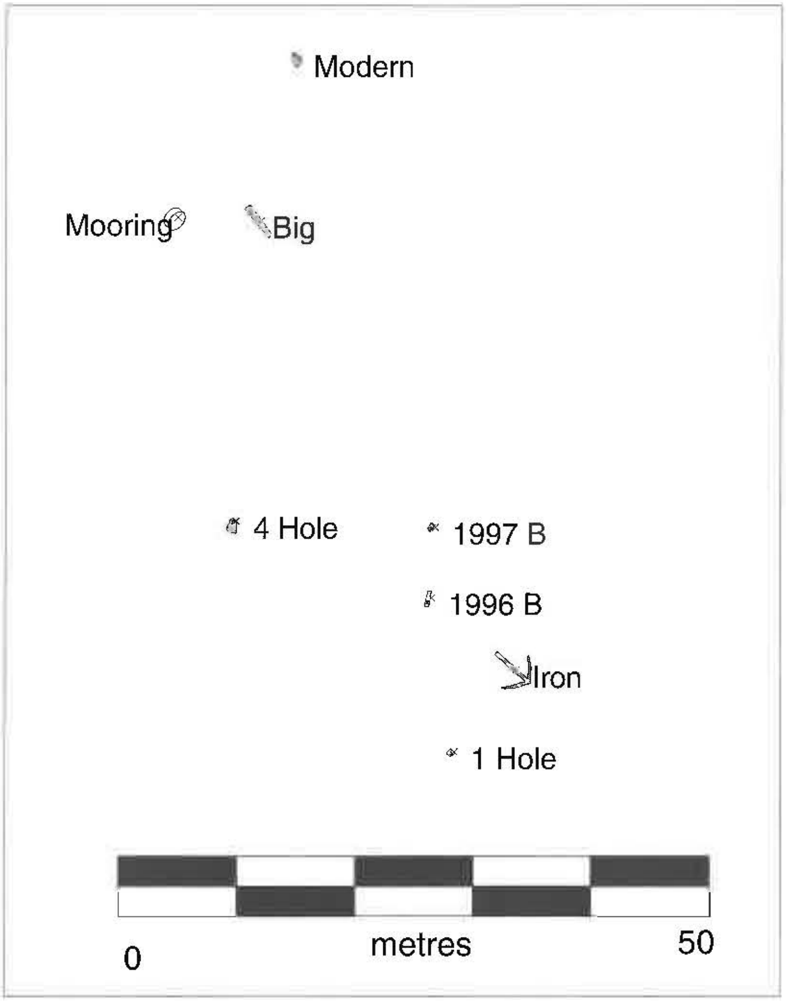
The large stone anchor GHP 30 was located first on 27 October, after using the Lihini rock transit and moving the search area SSE from the rock. A modern, concrete and metal mooring was located 5 m away from GHP 30. Another stone object, approximately 0.5 m in diameter, was found 14 m from GHP 30. In low visibility, this particular object was located by snagging in a circular search and the round hole felt in the stone suggested that it may be another broken portion of an anchor. After recovery, this object was identified as a modern mooring. A small, round hole has been machine-drilled, presumably made for a explosive charge to sit in. The rock appears to have been blast-quarried. A modern piece of chain was concreted to the surface of the rock.

On return to the site on 29 October, a third anchor GHP 32, previously unrecorded, was found. It is a flat tablet-shaped anchor with two round, vertically aligned holes at the top, and two square, horizontally aligned holes located in the lower half. Whilst the two round holes present as an unusual configuration, the shape is classically Mediterranean in style. The search continued in an easterly direction from this anchor leading to the discovery of a broken anchor GHP 31, 740 mm by 370 mm located 17 m away. This is the crown of an Arab-Indian anchor which has broken off at the second square hole from the top. The dimensions of this anchor were smaller than those of the broken anchor recorded during the 1996 expedition, suggesting that this was a new find, not the original example being sought. Samples from all three anchors were collected and sent to Colombo for petroglyphic analysis.

While conducting searches south of the large anchor GHP 30 position, three anchors including the previously located 1996 broken stone anchor and an 18th-century iron anchor were found on November 18. A round anchor GHP 76, with a diameter of 650 mm and height of 150 mm was also discovered. This anchor was essentially a rounded stone with a squared-off hole through the centre. The 1996 broken anchor was approximately 50 m from the large anchor GHP 30 position on a bearing of 175°, and 17.4 m from the four-hole GHP 32 anchor. Its dimensions are 1.32 m by 370 mm by 300 mm. The area in which these three anchors were found has been designated as Site T to distinguish between the two anchor sites.

Survey strategy

For survey purposes, the anchors were linked together with lines, which enabled divers to locate each anchor easily in low visibility. The relative positions for each anchor, the modern mooring and the rock outcropping from the sea bed were recorded by a measurement and bearing survey.




*Site plan of the anchor locations*

The positions were also staked in order to allow follow-up survey work after the anchors were raised. From the anchor positions, subsequent circular searches could be used to locate more artefacts and to better define the site by location and mapping of natural features. All measurements were determined using the least squares adjustment method, and the resultant co-ordinates plotted into a site plan.

Anchor recovery

In preparation for raising, the anchors were secured with rope. To facilitate the attachment of ropes, a water-jet was used to clear space under the large anchor GHP 30. During this procedure, a substantial piece of blackened hardwood timber was located. It was postulated that the wood was the anchor arm or stock, although initially the size in cross-section, as interpreted by conjectural reconstruction, suggested that it was to large for that purpose.

The anchors were raised on November 4, with the largest raised first. GHP 30 was bound in three places along the length of the shank, and a chain attached to the ropes so that the anchor could be winched by crane out of the water at the Navy Base.

*Recording the broken stone anchor*

Three drums were attached in a vertical arrangement initially; however, two more were required to float the anchor. Each drum had a lift capacity of 200 kg. Approximations of the weight of the anchor to 900–1 000 kg, had been made prior to the operation using the calculated anchor volume compared with the weight and volume of a similar piece of stone. The extra two drums were attached horizontally across the anchor. A problem occurred after filling, when the horizontal drums pushed the vertical drums to an angle which resulted in air loss during ascent. Consequently, the large anchor floated to the surface only to sink again. The problem was rectified by cutting the ropes free on one end of the horizontal drums changing their orientation to a 45° angle. After raising, the large anchor was towed into the Navy Base where it was winched out of the water by crane. The four-hole and broken anchors were raised, using one drum each, and towed to the Conservation Laboratory jetty and lifted ashore by hand. The last anchor, interpreted as modern was pulled to the surface by hand and also towed to the Laboratory jetty. All four anchors were then transported to the Maritime Museum for storage and deconcretion.

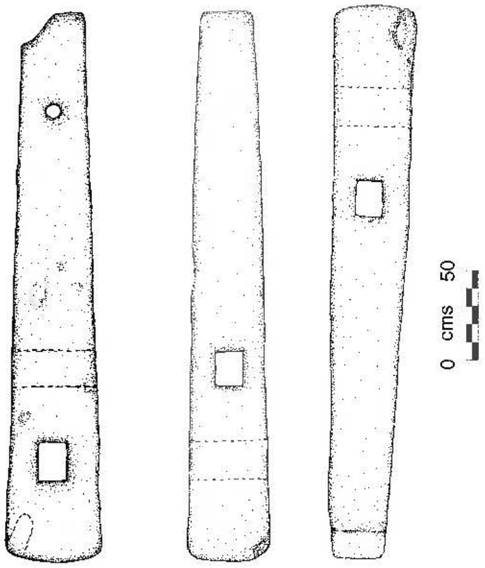
The round anchor GHP 76 was raised on November 24 by hand and taken to the Conservation Laboratory jetty for storage. This was the last anchor to be raised this season, although there are plans to raise the 1996 broken anchor in the future.

Stone anchor descriptions

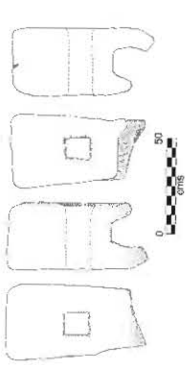
The position of anchors *in situ* can indicate trade routs, the system of navigational (Frost, 1977: 378) and ancient anchorages. In classifying an anchor, there is a tendency to compare typological features which attribute the style to a particular country. However, the identification of an anchor type or style in a geographical sense does not necessarily indicate its provenance. It is important to recognise that, while in some cases, this may be applicable, anchors to some extent were consumables, which would need to be replaced in foreign ports. Anchors were also trade items themselves. The collection of anchors in Galle Harbour include two distinct types: the Arab-Indian stone shank, and four-hole Mediterranean type. A cluster of anchors on the sea bed has been termed as an anchor graveyard (Frost, 1970: 385). Since Kamba Bandina Gala is a known mooring area, this accumulation of anchors confirms it is an anchorage site.

*GHP 30*

| | |
|---|---|
| Fabric: | Sedimentary polymict conglomerate |
| Maximum length: | 3.170 m |
| Maximum width: | 550 mm |
| Minimum width: | 260 mm |



*GHP 31*



Fabric: Sedimentary sandstone beachrock
Maximum length: 740 mm
Maximum width: 370 mm
Minimum width: 300 mm

The large (GHP 30) and broken anchors (GHP 31) are categorised as Arab-Indian. Similar examples are known from sites in the Western Indian Ocean—Mombasa, Malindi, Oman, Dwarka and the Red Sea. They are oblong in shape with a round hole in one end, presumably to take the mooring rope, and two square holes in the other end set at 90° to each other, one slightly further up the shank than the other. Through these opposite-facing holes, wooden stakes were set to act as the arms of the stock of the anchor. The type was initially identified by Honor Frost as 'grapnel' due to the transverse square holes in the lower part of the shank. This has been disputed, as the anchor shanks are rectangular in cross-section whereas shafts of four-armed grapnels are square or round (Kapitan, 1994: 2). There is a difference in size of the two square holes in the lower portion, which also suggests that these are not grapnel anchors. Kapitan has proposed a reconstruction where the larger hole near the end of the shank actually holds a stock rather than an arm (Kapitan, 1994: 2). The discovery of wood in association with GHP 30 evidences a different reconstruction. The *in situ* positions of the two baulks of wood in relation to the anchor holes indicates that the arm came from the hole nearest the crown. The lower hole holds a curved wooden arm and the upper hole holds a smaller piece of wood, which may be either an arm or stock.

The round hole at the other end of the shank would have had a rope directly tied through it, or perhaps another stock. The latter suggestion is qualified by other anchor examples such as a shank found in the Red Sea at Lone Mushroom, west of Ras Muhammed (Raban, 1990: 302). This anchor is rectangular in cross-section, but only has one rectangular hole in the lower part which passes at right angles to the axis of the circular hole at the other end. This arrangement suggests that the rectangular hole held the arm of the anchor while the round hole held the stock. A timber would be required in the round hole in order for the anchor to grip into the sea bed effectively (Kapitan, 1994: 2).

The anchors are pre-European and could date from the 5th to the 14th century AD. In the same general area is a site known to have ceramics from a wide geographical and temporal range. This material is possibly associated with the mooring of vessels and the stone anchors.

There are about three dozen stone anchors of the Arab-Indian type catalogued in the Indian Ocean and the Red Sea. The largest concentration has been found off the coast near Qalhat, Oman, in 1996. The Omani find was the greatest concentration to date and consisted of approximately 12 anchors or anchor fragments (Vosmer, 1997: 7). Twenty-four similar examples have been reported in India; however, all were being re-used as architectural elements in dock-works and forts (Tripati, 1997). Their occurrence within architecture presents us with an approximate datable context. While the anchor may have been made for incorporation into a building or for a votive use, the function of anchors as an architectural element is probably a secondary use of the object. The primary function of an anchor as of a ships or as a mooring anchor presumably predates their secondary usage. It is unwise to date the anchors' two uses as contemporary as they may have been incorporated into architecture after being abandoned years before.

There has been a wide range of dates presented for this type of anchor. Some scholars categorise them as Late Bronze Age (Nibbi, 1991; Frost, 1963). Generally they are termed Arab-Indian which attributes this particular form to the period 5th–10th century AD. Attempts have been made to compare them to earlier anchors such as the Temple of Isidorus finds from the Alexandrian Delta, which were considered by Frost to come from Roman levels (Owen, 1997: 5). However, when we recall Frost (1986) *Criteria for a Corpus* the anchors' shapes are neglected in such a comparison. Whereas the Roman example shares some common diagnostic features, it is markedly different in shape. The Galle Harbour anchors come from an unstratified site which prevents absolute dating. The Arab-Indian anchor is best understood by a comparative archaeological analysis of the corpus of similar finds.

*Wooden arm from stone anchor GHP45*

Timbers

Excavation of the area under the large stone anchor GHP 30 revealed timber consisting of two pieces of particularly dense wood, presumably a hardwood. Hardwood is strong and durable enough for anchoring purposes. This is the first time wood has been found in association with an Arab-Indian stone anchor. The discovery of timber will hopefully provide insight into the configuration of these anchors. The timber's position in relation to the stone shank and, in particular, the square holes, suggests that the wood functions as the arms of the anchor. The first piece raised is 980 mm in length and 160 mm at its widest point. The height is 104 mm. It was found approximately 300 mm under the sediment. There is no uniform stratigraphy as the first layers of sediment contain a random mix of broken ceramics and roofing tiles. The lack of stratigraphy implies that the area is, or has been, subject to a high degree of disturbance. The uppermost surface of the timber, as found *in situ,* exhibits curvature with the majority of the original surface intact. The surface also exhibits tool marks, probably those associated with adzing. The underside has been partially degraded by marine borers, although much of the original surface remains. The original shape of the timber has been retained and has a natural curve inwards on one edge, approximately 730 mm along its length. The curve of the timber has been tooled and the edges chamfered to shape an arm. It is difficult to ascertain the original shape at this end of the arm as a large section is missing. However, in profile view, the end appears to originally have been finished in a chisel point. With this in mind, the missing portion of timber may have been symmetrical with that which remains, together forming a long, gradually tapered, V-shaped anchor arm or possibly stock. The thicker end of the timber, which was found next to the shank, is mortised, and exhibits extensive degradation by marine borers. It appears that the mortised end has snapped off, suggesting that this piece is only a portion of the original timber. The function of the mortised end is unclear. It may have performed as a locking mechanism to secure the timber into the anchor shank.

The second piece raised two days later, is considerably larger than the first. It is 1.340 m in length, 260 mm wide and up to 180 mm high. The timber is similar to the smaller piece as it exhibits a natural curve which has been enhanced by tooling. The timber has retained its original surface, in part. Raised knots, up to 5 mm high on the upper surface of the wood, may indicate where the original surface was and the subsequent extent of degradation, although it is also conceivable that they were simply a natural part of the timber surface. The grain of the timber is visible on the surface of the thickest end. This end lay perpendicular to the anchor, under the stone shank just behind the crown. It is conceivable, regarding its position and condition, that it has broken off from another piece of timber. It may have also broken off from the hole in the anchor shank as it was excavated, from underneath the anchor shank. The curve of the timber begins 650 mm from the widest end to form what may be interpreted as an arm. There is also general degradation and possible wear contributing to the curve, which prevents a full understanding of the shape. The timber may have been selected for its naturally contoured shape and then mechanically worked to create an arm which would penetrate and grip into the sediment. The end appears to finish in a point, although this, too, is broken or worn. Tool marks are visible, particularly in profile, although not to the same extent as the smaller timber. The underside of the large timber shows evidence of degradation due to marine borers, with some of the original surface remaining. It curves upwards contributing to the hooked-arm appearance of the timber. Timber samples have been collected for identification and dendrochronological analysis.

The nominal holding power of an anchor is related more to the size of the flukes than the weight of the shank. The addition of wooden flukes would, therefore, increase its relative holding power (Vosmer, 1997: 8). The timbers, as we found them, are incomplete, which prevents overall size determination. Both pieces are too small to fit well within the square holes. The timbers do not appear to be heavily worn and may be close to the original size. It is also likely that the timber has swelled since immersion. If this were the case, the arms may have been secured in the holes by a wedge. It has been suggested that the wooden anchor arms may have been sheathed in iron; however, the find in Sri Lanka does not evidence this. The Arab-Indian anchor, as interpreted by Raban, was shaped for a safer anchorage in a coral sea bed, like those fringing the Indian Ocean. He also states that this style of anchor may not have been confined to Arab boats or necessarily the result of Arab influence (Raban, 1990: 303).

It is believed that large vessels would carry a complement of anchors that would be used both to secure the ship (Frost, 1983: 357) or to replace those lost. In high-sea conditions, it was common practice to throw an anchor and drag until the rope snapped, and repeat this action until the ship was securely anchored (Owen, 1997: 5). A vessel, therefore, carried several anchors to be used if one were lost, or to be used in conjunction with each other. The sheer size of these Arab-Indian anchors suggest that they could not easily be pulled up by hand. It is assumed that, as a result, many anchors were abandoned (Owen, 1997: 5). This is one explanation for the collection of anchors we find in Galle Harbour.

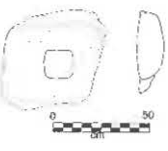
On the other hand, we know that this site was a traditional mooring ground, which supports the idea that large Arab-Indian anchors were not intended for use as working ships' anchors (i.e. to be cast from on board), but rather as mooring anchors. This may explain the deployment of the large complete anchor GHP 30, with an estimated weight of 1 000kg. It's position in-shore gives credence to the idea that mooring anchors were laid carefully from a floating platform using a pulley system (Kapitan, 1994: 4). In contrast, the oft-cited 8th Century Cypriot vase showing a stone anchor being lowered from a ship by a boom indicates that this method of deployment was also conceivable (Frost, 1970: 392).

A series of fixed moorings in the Kamba Bandina Gala area would have provided ships with a useful anchorage within the harbour. The devising of such a system of moorings may have been imported by traders, as there were generally very few harbour facilities in the western Indian Ocean (Kapitan, 1994: 4). The adoption of a submerged mooring facility within the pre-existing harbour at Galle suggests a precautionary measure of ensuring vessels were secured when lightering cargo. However, the discovery of the remains of wooden arms in association with GHP 30 does go against this theory as, technically, arms would not have been necessary (Frost, 1970: 392). Similarly, they would not stand up to long-term immersion. While there appears to be no justification for arms on a mooring anchor, all these large Arab-Indian examples are designed as composites.

*Shank of stone anchor GHP30 and timbers GHP44 (right) and GHP45 positioned as found in situ*

Both explanations of how this site came into existence are valid, as little is known about the *in situ* conditions of these sites. These hypotheses, however, do not explain the purpose of the broken anchors. They may have been used as mooring anchors after they were broken; in this context, an example of secondary use. They also may have been dumped, if local replacements had been obtained. A comprehensive analysis of the relationship of the anchors to one another as they lie on the sea bed may begin to reveal whether the *in situ* configuration denotes a formal mooring anchorage. The size of GHP 30 has prompted the suggestion of this site as a possible formal mooring ground. In such an instance, the size of a range of contemporary vessels cannot be calculated from the weight of such stones if they were intended as mooring stones.

*GHP 76*




Fabric: Sedimentary sandstone
Maximum length: 650 mm
Maximum width: 490 mm
Maximum thickness: 150 mm

GHP 76, on first examination, was interpreted as a round stone anchor with a single square perforation. The round anchor is possibly a weight anchor. This type relies on its weight, as opposed to arms, to hold a vessel. Its shape and size may indicate that it was used for a small vessel on a rocky sea floor (Vosmer, 1997: 9). However, the shape of the hole is squared off, perhaps so that a wooden arm or stock may be inserted. Apical holes may also be squared off as in the Late Bronze Age Ugaritic anchors (Frost, 1970: 388); however, the purpose of this square finish is unclear. The holes in the Ugaritic examples are cupular drilled, yet chiselled square on one side, perhaps to lock the wood in place and stop it rotating loose. This technique was interpreted as decorative as, in this instance, the original drill holes are narrow and round and not cut to fit square flukes (Frost, 1970: 388). There is no evidence to support this in other single-hole anchors; however, square holes in the tablet, Mediterranean-style anchors have generally denoted the use of wooden arms. It is not necessary to square off a hole if it is to be used for a hawser alone.

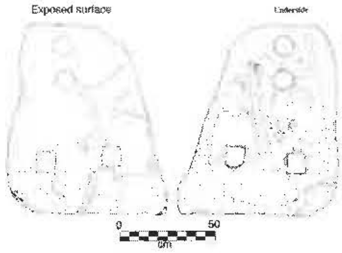
The shape of the anchor has some similarities to the ringstones used in the Maldives. Ringstone anchors were used for anchoring on coral reefs to prevent snagging on the coral. A forked branch could also be inserted through the hole of a ringstone operating as a crude shank (Vosmer, 1997: 17).

Both ideas concerning the identification of this anchor fail to address where it was found. The silt and sediment sea-floor of Galle Harbour does not support either theory—of it being a rock or a coral anchor. Its function as we find it *in situ* is probably as a temporary mooring or abandoned anchor from a smaller boat. It is possible that it is not in its original form. It may be a fragment, such as the lower corner of a Mediterranean three hole anchor, similar to GHP 32 (Vosmer, pers. comm.). That would explain the square hole and the unusual shape.

The closest comparison to this anchor comes from Kommos in Southern Crete, and comes from a definable chronological context (Shaw, 1995: 282). It was dated to the late Minoan Period of 1250 BC (Nibbi, 1993: 13). The Kommos example, artefact no. S636, is one of five anchor fragment finds, and it exhibits the same characteristics, including the squared-off hole, as the one found in Galle. It is approximately the same size, which would preclude its use for anything more than as a light-weight anchor for a small fishing vessel. The Kommos example has been reconstructed as a triangular one-holed anchor, which was common to the Minoan Period (Nibbi, 1993: 14). This type of anchor is also in use today, which makes dating this object difficult.

*Sri Lankan conservators deconcreting stone anchor GHP76*

*GHP 32*




Fabric: Sedimentary sandstone
Maximum length: 1 m
Maximum width: 830 mm
Minimum width: 400 mm
Maximum thickness: 170 mm

This object is interpreted as a four-hole composite anchor which essentially means that the anchor does not rely on its weight alone (Nibbi, 1991: 191). The type has also been labelled Byzantine–Arab as it was common to this period (Frost 1963: 49). It was still in use up until recently in the Persian Gulf and on Arab boats in the Mediterranean, and, as a result, has been called Mediterranean in form (Frost, 1963: 13). This type appears in many varying forms across a broad geographical and temporal range.

Its type's interpretation as composite has recently been evidenced with the discovery of wood remains within a three- hole stone anchor from Crusader Arsuf (Appollonia) in Israel. The wood is radio-carbon dated to AD 1164–1253 (Grossman, 1996: 51). The Israeli anchor is slightly smaller in dimension, with tubular piercing in the base of the anchor, as opposed to square. Wood remains were discovered in one of the lower holes (Grossman, 1996: 50). The wood had been sawn carefully to fit the holes, and sat flush with the surface of the anchor on the upper and presumably underside. The condition and position of the wood *in situ* suggest that the anchor was deployed without the envisioned large wooden flukes protruding well beyond the surface of the stone (Grossman, 1996: 52). This find would, therefore, support the idea that composite anchors were used without the arms complete, in some circumstances.

Wood has been found in association with stone anchors in two other instances. The Israel Antiquities Authority reported a three-hole anchor, with a section of a fluke in a lower hole, retained by iron nails. Wood has also been found in association with medieval two- and three-hole anchors from Agde, France (Grossman, 1996: 51).

The anchor GHP 32 shares characteristics with examples found in India in relation to the hole configuration and general shape. The Indian examples, in particular those from Sindhudurg Fort on the west coast, are, however, more triangular in form. The date range for this form in India is from 2300 BC to the Historic Period. Their Mediterranean and Egyptian counterparts are dated to 1200–1400 BC (Tripati, 1997: 55).

The GHP 32 anchor has a pock-marked surface, a result of exposure and encrustation. Only a small portion of the original surface remains. The anchor has two round holes below the apex and two square holes along the base. It is generally accepted that the top hole(s) in the anchor were for the main hawser. This is an unusual example as this style of anchor, as found in other contexts, has only one round hole below the apex. This may be a deliberate double-hole configuration to ensure the anchor stone is secured to the lifting rope or perhaps the lower hole was added later to replace the original hawser, which is liable to break as it is only 45 mm from the top of the anchor.

The number and configuration of holes on this type of anchor may be a result of the way the anchor was transported on board a ship, rather than the type of sea bed on which it would eventually rest (Nibbi, 1993: 9). The anchor as we found it *in situ* has random channels cut into the surface, possibly wear marks from general use—the hawser rope or ropes which tethered it to the sea floor or to the ship during transportation. The square and round holes also show signs of wear.

Petroglyphic analysis

The stone sample from the large anchor GHP 30 has been identified as a sedimentary conglomerate. The major part of stone local to Sri Lanka is igneous. The conglomerate is quite common in alluvial fan or fan delta complexes flanking rising mountain fronts or fault scarps. The most probable source of the anchor stone, from initial inspection, is Oman, as similar conglomerate formations occur along the mountain front running along the Oman coast-line (Gunatilaka, 1997: 2).

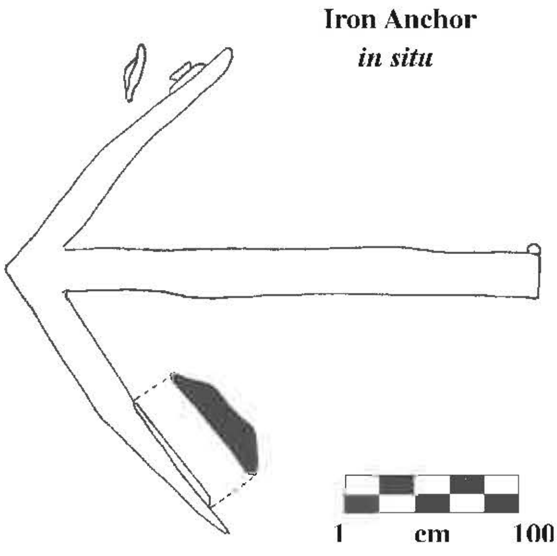
The broken GHP 31 and four-hole GHP 32 anchors are sedimentary. GHP 31 was probably formed from a beach sand that is common to many coastal areas making the provenance difficult to determine. GHP 32 is also a beach-rock made up of shelly material and quartz. This type of stone is common to the Arabian coast, from Abu Dhabi to Kuwait (Gunatilaka, 1997: 3). Samples have been removed from each of the anchors to identify the type of stone, its porosity and possible origin.

Of the four stone anchors sampled, the sample of the biggest (GHP 30) is the most unusual as it is derived from a conglomerate formation. Initial inspection by the geologist (Gunatilaka) has resulted in a tentative source identification of Oman. A selection of individual pebbles bound in the cementing matrix of the anchor stone were collected to permit a more reliable identification. Following the removal of samples, freshly exposed surfaces of each of the three anchors were tested with dilute sulphuric acid (5%) to ascertain whether or not the binding matrix was calcareous. This proved to be the case for each one. All samples were removed by a chisel, and the sites carefully chosen to minimise alteration of the appearance of the anchors.

An example of a ballast stone from the unidentified wreck at Site G was fragmented by the geologist to facilitate identification of the stone. A further selection of stone was gathered from this site to provide comparative material and to ascertain if other types of stone form part of the ballast. A sample was also removed from one of the large naturally occurring boulders at the site for comparison.

*Stone anchor GHP30 wrapped in hessian and polythene*

Large iron anchor *(in situ)*




A large iron anchor which appears to be of the Old Plan Long Shank pattern, similar to examples from HMS *Sirius* wrecked in the South Pacific at Norfolk Island in 1790 (Stanbury, 1994) was found in the vicinity of the stone anchors discovered previously.

**Conservation**

Stone anchors

The main conservation concern has been the issue of the stability of the stone anchors following recovery. Since a proper examination could not be carried out prior to recovery to ascertain the likely porosity of the stone, precautions were taken to ensure that the stone did not dry, thus avoiding potential damage due to salt crystallisation. A wrapping of polythene sheet and water-soaked jute bags (Gunny sacks) was used to maintain a moist environment for the anchors.

To lift the large Arab-Indian anchor (GHP 30), it was bound with ropes to avoid damaging the surface, none of the original holes (for arms and hawser) were used for this procedure (other than to prevent the lateral movement of ropes during the actual lift). Chains holding the lift drums were attached to the ropes in order to prevent damage to the stone. The actual lift was not without problems, but the anchor appeared to have suffered no damage as a result, and it was successfully brought alongside the Dakshina Naval Base wharf. A crane transferred the anchor from the water, placing it onto wood supports covered with a layer of polythene and a bed of sea-water-soaked sacks. After wrapping in these materials, the anchor remained moist and secure on the wharf overnight. The next day, following an assessment of the stone's condition and durability, the soft marine growth and dirty harbour sediments were removed by the use of a high-pressure water blaster (this made the subsequent work of cleaning off marine encrustation much easier and pleasant as it minimised the products and odours of decay). On completion, the anchor was moved on the padded tines of a fork-lift, to padded supports on the back of a truck and transported to the Maritime Museum in the Galle Fort.

Removal of the marine encrustation (mainly oyster shell, maximum 50 mm diameter) from the biggest stone anchor took some two and a half days. Five conservators used an assortment of chisels and hammers to remove the shell deposits. The procedure took place outside the Maritime Museum in the Galle Fort.

To avoid potential problems attributable to the crystallisation of salts, all of the anchors were regularly wetted down using a fresh-water hose and buckets of water, assisted by periods of rain.

The three smaller stone anchors GHP 31, 32 and 76 have been placed in the concrete storage tank located on the jetty of the Conservation Laboratory. To permit desalination to take place, this tank is partly filled with fresh water and will require topping up occasionally to ensure the anchors remain fully immersed.

The porosity, and, therefore, potential salt contamination, of the stone of all the anchors has yet to be determined. Total immersion of the largest anchor in fresh water is desirable, but requires the building of a concrete tank or alternatively a hole dug in the ground fitted with a waterproof lining. The anchor could simply be suspended from beams across the hole. Just prior to the team's departure from Galle in 1997, the decision had been made to build a tank to house the largest anchor. If the porosity of the stone is insignificant, the anchor should have, at the very least, a regular fresh-water dousing (daily if possible) to wash away surface salts. As with all artefacts, regular inspection must be carried out to determine whether any problems are developing.

Condition of the anchors

All the anchors recovered required removal of some encrustation, which comprised mainly of bivalve mollusc shells (oysters). The upper surfaces of the largest anchor GHP 30 were densely covered in these and were colonised by hydroids. The less durable surface of the broken anchor GHP 31 had been quite extensively penetrated by boring bivalve molluscs. Anchor GHP 30 also had some examples of this mollusc present.

*Stone anchor GHP32 being transferred to conservation tank for desalination*

The other anchors GHP 32 and GHP 76 were less encrusted due to their lower profiles and partial burial in the sea bed. General sediment disturbance close to the sea bed and probable cycles of burial and exposure appears to have inhibited colonisation by long-term marine organisms.

The actual stone of all the anchors remains in good condition. Prior to removing encrustation, the surface of each anchor was examined (test probed) to ensure due care was taken when chiselling away encrustation. The sedimentary stone of GHP 30, GHP 31 and GHP 32 is less durable than that of anchor GHP 76 and the modern example, which appear to be derived from igneous rock. In general, the stone surfaces exhibit areas of wear and damage, but no more than might be expected considering the working life of anchors. Long-term immersion in the marine environment and colonisation by marine biota have contributed by degrading and pitting the stone surfaces. The surface of anchor GHP 76 is quite badly degraded to a depth of approximately 3–4 mm. A sample of this stone reveals a very hard and crystalline interior structure, quite different in appearance and colour from its outer surface. The degradation of the surface would

*Wood samples from GHP44*

*High-pressure water jet being used to clean stone anchor GHP30*

imply long-term immersion for this stone anchor; if the rate of breakdown of this stone type can be determined, then it may be possible to date it.

*Large anchor* in situ

A conservation condition assessment was carried out on the large iron anchor left *in situ,* which included pH and corrosion measurements. The anchor is substantial in construction and appears to retain much of its strength. The concretion layer, which encapsulates the anchor, averages 15 mm thick. So, apparent dimensions are not significantly different from actual dimensions. The anchor is 3.17 m long and 3.9 m across the arms. The shank and arms are approximately 200 mm in thickness. The very end of the shank to which part of the ring appeared to be attached may be missing. The palm of the exposed anchor arm appeared to be partly broken away and the other arm is buried.

| | |
|---|---|
| Site depth | 6.9 m |
| Water temperature | 30° C |
| pH sea-water | 8.82 |
| pH sea-water (shift) | 8.72 |
| $E_h$ sea-water | -116 |
| Concretion (mm) | 15 mm |
| Gas evolved | yes |
| pH (under conc.) | 5.51 (hole 1) |
| pH (under conc.) | 6.07 (hole 2) |
| $E_h$ (metal) | -577 (hole 1 and 2) |

Timber

The discovery of wood (GHP 40 and GHP 41) associated with the large stone anchor is a unique and important find. Despite only relatively shallow burial (300 mm approx.), the wood has endured perhaps several centuries of immersion in the sea (water depth 7 m ). The wood appears to be a dense and strong hardwood, which are predictable attributes for anchoring purposes. The burial medium is sand and finer sediments intermixed with broken ceramics and an assorted collection of objects from recent and past times. The diverse and random vertical mix of old and new objects in the surrounding sea bed implies that the area is subject to considerable periodic disturbance, which makes the survival of this wood all the more remarkable.

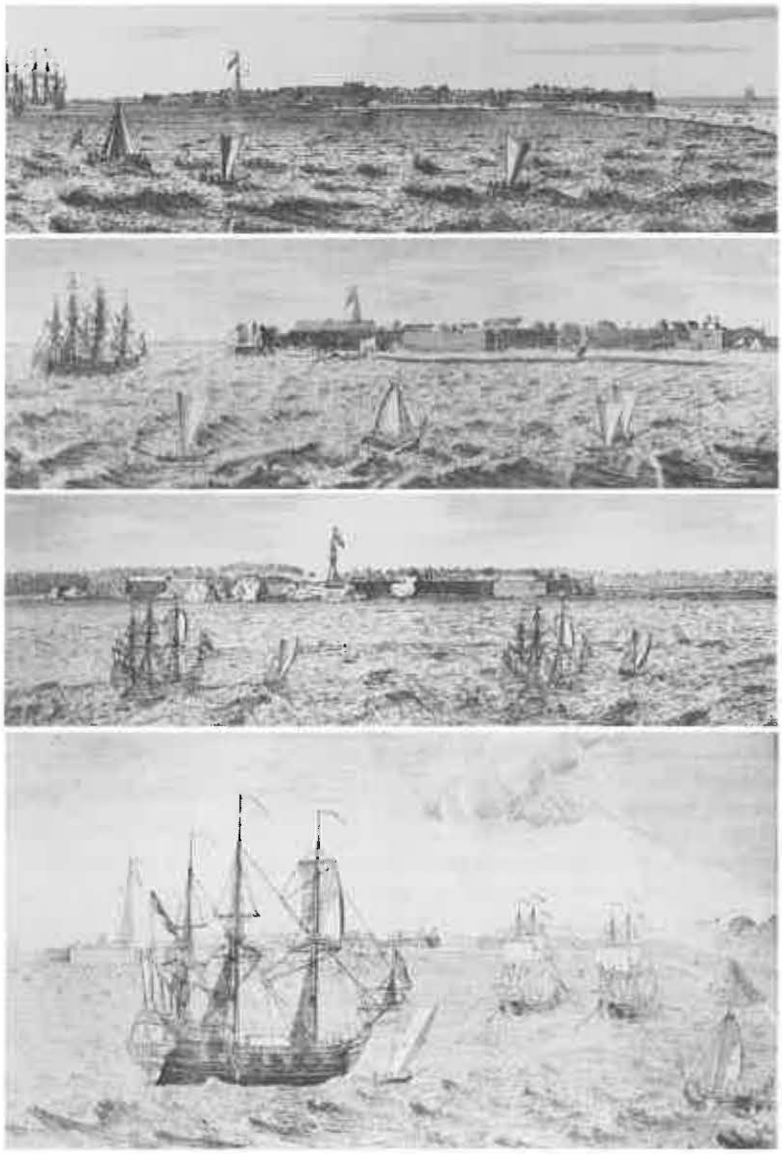
The relatively compacted sediment, and the blackened appearance of the wood imply that anaerobic conditions were prevailing at the time of discovery. The under surfaces and one end of both pieces have suffered some marine borer attack, and this would indicate that aerobic conditions existed some time in the past as teredo cannot survive burial in anaerobic conditions. Alternatively, it may be the result of attack incurred when the anchor was in the original 'set' position. The latter conclusion may be correct as the most extensive teredo damage has occurred on the ends of the wood which were closest to the stone shank of the anchor, but not on the opposite ends. At the time of discovery, the largest of the two pieces of wood lay partly under the shank just behind the crown. It is probable that this wooden arm became trapped as a result of collapse due to this original borer activity.

The condition of the wood is very good. It still exhibits original surface working (adzing) and retains original shaping (curvature and chamfering). Other than the teredo damage, it seems that only 1–2 mm of the outer surfaces show obvious degradation as the bulk of the wood still has the toughness and solid 'ring' of seasoned wood. Rounded-over, knot-like projections on some surfaces of the largest piece of wood (GHP 45) do not appear to be less degraded areas but typical wood-growth formations which are frequently visible when the bark has been removed. A moist storage environment is being maintained for the wood to avoid possible shrinkage and cracking despite its apparent integrity. Controlled drying may be possible for the wood; however, the experimental nature of this procedure and the risk to such a rare find would negate this option until the extent of degradation has been accurately determined. To optimise success, the recommendation at this stage would be to conserve the wood with PEG and freeze-dry it. This conservation procedure should preferably be performed at a conservation facility with recognised expertise in this field of treatment.

In view of the proposed sampling requirement for this wood, further intrusive drilling to acquire pH profiles was not contemplated, to avoid marring the appearance of these unique finds. A selection of samples has been acquired from each piece of wood for degradation analysis, species identification and dating. After cleaning, each sample was placed in a vial of fresh water. No biocide was added, to avoid contamination which affects dating investigations.

Wood in a similar state of preservation is also found at another site in Galle Harbour. The wreck at Site L, believed to be that of the *Avondster*, was lost in 1659. A considerable amount of this vessel's timbers and, coincidentally, a wooden anchor stock (attached to an iron anchor) have survived almost 350 years' immersion. The wood from the Arab-Indian anchor GHP 30 appears to have survived in equal, if not better, condition. Unless this earlier type of stone anchor was in contemporary use in the mid-17th century, the two wooden arms recovered may have survived some 500 years or more in the sands of the Galle Harbour anchorage.

Both pieces of wood were prepared for proposed transportation to the Department of Materials Conservation, Western Australian Museum, for conservation treatment. The shells of marine animals, including uninhabited Teredo worm tube, were removed with the aid of dental tools, and the wood surfaces gently brushed and rinsed to clean away clinging sea bed debris. During this procedure, the wood was frequently wetted to prevent surface-drying. After cleaning and sampling, a solution of BDH Panacide (a biocide) was applied to the wood surfaces to eliminate any living microscopic organisms and prevent the development of bacteria and fungi during storage. Sterile bandages were then wrapped around each piece of wood and re-soaked with the biocide. Each was wrapped in polythene sheet, sealed with tape, and bound in several layers of protective foam. A further layer of polythene was then sealed around each of the parcels of wood.



*Illustrations from the Atlas of Heydt (1744) above and Schouten (below) showing the process of bringing a VOC ship into anchor at Galle. Notice the local dhonis going out to the vessels anchored off the Fort. Also the for and aft mooring system for the ships anchored in front of Closenberg. Below the vessels are anchored in front of the Black Fort*

**Conclusion**

The region surrounding Site P and Site T is a formal mooring or lightering site for Galle. The discovery of these anchors indicates a continuity of use of this area. Anchors were designed for holding a vessel's position in mid-water rather than alongside the land. In light of this, an anchor represented a means of stopping a ship effectively where there was no mooring available or possible (Nibbi, 1993: 11). The variety of anchors discovered in close proximity to each other in Galle Harbour leads one to conclude that a specific type of anchor was selected to suit the mariners' requirements, the ability of a ship to transport the particular anchor type, and the availability of materials, i.e. broken anchors re-used as moorings.

**Site O (target no. 60)—Iron shipwreck**
This iron vessel is located in 13.8 m of water. The surrounding sea bed consists of course sand formed into comparatively large sand waves (approx. 400 mm high). This indicates considerable water movement and surge at depth. The 10+ m underwater visibility at the time of discovery permitted a good, although time-restricted, initial swim over the structural remains of the vessel. Its size was estimated to be approximately 30 m long by 10 m wide. It is likely that the vessel has been extensively salvaged as well as being affected by the site conditions mentioned. It will be interesting to compare conservation data from Site A (shallow in-shore zone) with that from this deeper wreck site.

**Site Q—Iron wreckage**
Iron wreckage, including some chain, pipes and large rings, was found strewn amongst a large clump of rocks (maximum height 5 m), with the typical sand sea bed continuing to the south-east where a rectangular piece of iron was located. The approximate depth to sediment was 12 m. The exposed iron was encrusted with a dense, uniform concretion layer with secondary colonisation by fouling organisms.

**Site R—Anchor**
The site comprised of the siliceous sand sea bed typical of the Galle Harbour area, with two separate clusters of large rocks. An iron anchor was found nestled toward the edge of one of these clumps of rocks.

*Iron wreck Site W*

**Site S—Iron wreckage**
The site was characterised by a very large cluster of boulders surrounded by sand. The maximum water depth was approximately 12 m. Iron concretions were strewn over an area approximately 5 $m^2$, 28 m from the marker buoy on a 230_ back bearing.

**Site U (Target no 41)—Large mound of boulders with artefacts**
Bottles were found in sand patches between the boulders around the periphery of the central rock mass. It appeared that the artefacts had accumulated here after rolling across the sands which surround the rocks. No evidence of any shipwreck was seen.

**Site v (Target no 24)—Iron anchor stock and other artefacts**
Artefactual material on this site lay scattered over a sea bed formed mostly of rock (maximum height approximately 500 mm) surrounded by sand. Although a few iron fittings (including an anchor stock) were present, no substantial remains of a wreck were found. A sand patch surrounded by a wall of rock-like substrate was seen, which may have been a depression left by a wrecked vessel. If this site was originally a wreck site, it is likely that it has been extensively salvaged; if not, it may represent an area where damaged cargo has been dumped. Artefacts recovered from this site (glass bottles and ceramics) were in relatively good condition and two grindstones were noted.

**Site W—Iron wreck, Watering Point Bay**
**Site description**
In March 1997, during the magnetometer survey of the eastern side of Galle Harbour, an extensive and strong anomaly was detected approximately 350 m to north of the Watering Point beach. The bay is characterised by a sea bed that slopes gradually away from the shore until it reaches a depth of 6 m. This area supports a wide diversity of fish and hard coral species, probably the richest in the whole harbour area. (In one area of 8 m diameter, at least 20 species were clearly identifiable). The sea bed then slopes more steeply up to 8 m and becomes an area of soft sediments and little visible life. This soft surface-sediment, typical of much of the harbour area, is a major contributor to poor visibility for the working diver.

**Archaeology & history**

During the November expedition, a snorkel-dive search was undertaken of the anomaly area. This showed some scattered iron ship structure, partially encrusted with coral at the northern edge of the coral concentration area. It lies at a depth of 4–5 m. A search in the 6–8 m depth, at the edge of the deeper slope, revealed an area of wreckage stretching for at least 60 m to the north-west. Four lengths of ship's hull and frames were in approximate alignment, suggesting continuous structure beneath the soft sea bed. The frames were 600 mm apart. At the south-east end of the hull structure were three possible deck supports. Nearby, the double head of a small engine or pump was located against the hull.

At the north-west end of the visible site, a massive 2 m-long, curved iron 'beam' protruded from the sea bed. Nearby was a 1 m by 2 m piece of hull, apparently the opposite side of the ship to the main structural length. This section was dubbed 'Lion Fish Lair', as it provided shelter for a number of these beautiful, but poisonous fish. Although it is tempting to label this area 'the bow', further investigation is needed to identify any of the structure so far seen.

A brief site survey, using tape and compass, was made by the Sri Lankan trainees at the very end of the expedition. Although visibility was poor, some photographs were taken and all features were recorded on video. This video record included continuous traverses of the site, supplying visual details to supplement the limited survey. The isometric site plan was produced using this data.

Although the site would be known by some local fishermen and shell collectors, no information has yet been found on the identity of this ship wreck. The limited visible structure gives the impression that it might have been some sort of barge.

The site has excellent potential as a class room site for archaeological training. Probing and limited excavation will be needed to determine the extent of the site and to provide further details of construction.

*View of Galle showing the old Point of Galle (foreground), the lighthouse and the Mosque (white building left of lighthouse)*

# TRAINING PROGRAMME 1997

*Scuba equipment training session*

### Training objectives

In association with in-water practical sessions, tutorials, workshops and video presentations were held to teach various aspects of underwater archaeology. The trainees were expected to produce individual workbooks to detail the exercises they had completed and to write up the practical workshops in which they participated. Individual assessments of each trainees' skills in five categories were made progressively, with a final assessment at the completion of the programme.

*Pool training*

*Dry run tape survey*

### Facilities

The training programme benefited greatly from the facilities provided at Nooit Gedacht Hotel, Unawatuna. A large area was set aside exclusively for lecturing and as a work-space for the students and trainers. Generous work surfaces were available, with good lighting, in close proximity to the accommodation areas. The computers were set up in this area, and it also functioned very successfully as a meeting-room for discussions and briefings on the day's activities.

The advantages of the students and trainers living in close proximity not only to each other, but to the 'classroom', the ocean and the underwater sites, were constantly evident. Organisation activities, maintenance of equipment and preparations for underwater work were all simplified due to this environment. The diving equipment was maintained, cylinders filled and survey equipment prepared for the next day, in the grounds of Nooit Gedacht. An extensive grassed area proved ideal for 'dry run' survey exercises. The small swimming pool also proved useful in the initial stages, to familiarise the trainees with the Project's new scuba equipment.

### Trainees

PRADEEP, Kumarasinghe Tennegedara
CHANDRE, Wijamunige Chandraratne
DAYA, Abesin Mallawa Arachchige Dayananda
ASOKA, M.A. Ashoka Perera
PALITA, K.D. Palitha Weerasinghe
CHANDANA, K.B. Chandana Weerasena
KDS, K.D. Somasiri Silva
RUKSHAN (volunteer), Rukshan Amal Jayewardene

### Programme outline

The program began on Monday, 20 October, with a general discussion to explain the objectives of the training programme and the expectations of the trainees. The students were encouraged to express their interest in particular areas or skills that they wanted to develop during the training. Their diving experience was noted, and a general indication of the level at which to begin the programme was ascertained.

Discussion included:

- Current occupation and main duties: archaeological vs. administrative; any experience with drawing (artefacts, site plans); surveying; photography; conservation; registration; etc.

- Identifying particular interests and skills: drawing (artefacts, site plans); photography; on-site conservation; artefact registration; surveying; etc.
- Diving qualifications: discussion of type of dives which would be encountered during the course.
- Total dive hours in open water.
- Date of last dive.
- Medicals: health issues—ears, sinus, other issues since 1993 medical.
- Snorkelling diving activities since qualification.
- In-water accidents, near misses, particularly difficult dives.
- Questions.

The following outlines the topics covered over the six-week period.

Topics were not necessarily presented in this order.

Assessment of equipment and in-water abilities

- Scuba qualifications, in-water experience and medical examinations
- Assessment of available equipment (practical)
- Range of tasks to assess in-water abilities (practical)
- All trainees completed diving medicals at the ENT clinic at Karapitiya Teaching Hospital

Advanced diver training

- Dangerous marine hazards
- First Aid rescues
- Compressors and cylinder filling
- Hookah-training
- Boat-handling
- Knots: under tension and not under tension
- Underwater navigation: compass underwater terrain etc.
- Carrying equipment underwater, rope entanglement.
- Low-visibility diving

Historical Aspects

- Scope of maritime archaeology
- Legislation
- Shipbuilding (basics of wooden ship construction; recognition of major vessel parts)
- Historical information to support archaeological research
- Integrated historical-archaeological research
- A reconstruction of one year's activities in the Galle Harbour

Recording

- Underwater photography
- Registration cataloguing

*Classroom session at Nooit Gedacht*

- Artefact photography
- Artefact drawing
- Computers (databases, Global Information Systems (GIS), drawing, scanning, adding text, site plans etc.)
- Publication
- Proformas: wreck inspection, site condition, conservation

Search and survey above water

- Magnetometer
- GPS, DGPS
- Chart reading, plotting

Underwater search and survey

- Visual search techniques
- Swim line search using jack stay and transits
- Swim line search using compass and transits
- Circular jack stay search

*Student water dredging on Site G*

*Dive boat on Site W*

Pre-disturbance survey (two-dimensional)

- Objectives of a pre-disturbance survey
- Priorities of a pre-disturbance survey
- Dry land run, two- tape trilateration
- Ocean, two-tape trilateration
- Right angle offsets

Considerations before excavating
Excavation techniques *(theory)*
Excavation techniques *(practical)*

**On-site conservation**
Site work undertaken
The trainees were expected to record their activities in the same manner as the archaeological team. To this end, students entered their dive profiles and survey information into the expedition databases on completion of a day's diving. This was, in part, an instruction in the use of databases as well as the necessary recording of site information.

Trainees participated in archaeological activities on each site assisting and working alongside the professional team. The following sections review their activities on each site.

*Trainees drawing stone anchor GHP 32*

Site P (Stone anchor site)
Students assisted archaeologists in the relocation of the stone anchors, using search techniques previously taught. Each of the trainees participated in the recovery of the five anchors from Site P.

The students were given the task of assessing the options for moving the heavy artefacts and working as a team to transport them in a manner that presented minimal risk to the artefacts and to the participants in the operation. The anchors were successfully recovered and transported.

A team of trainees planned and executed a survey incorporating measurements and bearings. In very poor conditions, where visibility ranged between 0.5 m–1.5 m, they collected the appropriate measurements to draw up a site plan. The students drew up the results of the survey incorporating measurements previously collected by archaeologists. A scaled plan of the orientation of the anchor positions, in relation to each other, was produced.

Other activities on the site included:

- Circular jackstay searches around the anchor sites to locate other artefacts;
- Circular jackstay searches around the mooring buoy to locate anchors;
- Use of visual transits and circular jackstay search to locate the possible position of other stone anchors;
- Differential GPS of anchor positions;
- Circular jackstay search from the mooring buoy to locate another anchor seen on the previous day. Upon location, the new anchor, which was identified as modern, was buoyed and surveyed;
- Water dredge around large anchor for timbers;
- Assisted conservators in anchor treatment and storage;
- Raising of anchors from Sites P and T. Students assisted in raising the round and modern stone anchors by hand. The remaining iron and broken anchors from Site T were drawn *in situ*. Trainees were present at the Conservation Laboratory jetty to collect the anchors after they were raised;

- Trainees observed on-site corrosion and pH measurement collection, and were familiarised with conservation equipment.

Site G (Ballast mound site )
- Trainees assisted with the movement of ballast stones away from the excavation area, in preparation for dredging. Located and surveyed sheathing found near point A and observed water-dredge activities;
- Offset survey: after laying a measuring tape along the baseline, two buddy pairs took a series of right-angled offsets to map in the natural features (boulders) on the cliff side of the baseline. These measurements will enable the new survey area to be located on the site plans of previous expeditions. This exercise enabled the trainees to undertake a survey unassisted, and then to process the data;
- The trainees were instructed in site-plan construction and produced plans of Site G using measurements previously acquired during offset surveys;
- Excavation, water-jetting and probing of grid square to determine the extent of the ballast mound;
- Artefact drawing of objects from Site G.

Site W (Iron wreck)
- During the investigation of a magnetometer target between Watering Point and Jungle Beach, a 20th-century iron wreck was discovered, in 6 m–8 m depth. Partial survey and dredging was performed by the students;
- In the wreck inspection practical segment, the trainees were divided into two teams of four divers to conduct an unassisted wreck inspection of the iron wreckage. The aim of the exercise was to assess the trainees' level of competency to plan, organise and complete a specific diving task; collect data; and complete a wreck inspection report. Each team reported their findings and completed a site plan of the wreckage. Both teams then collaborated to produce a general arrangement of the spread of wreckage. The trainees discussed problems they had experienced with executing the task and omissions in data collection.

Dewatte Beach magnetometer survey
- Prepared for manual magnetometer survey of Dewatte Beach. Trainees took DGPS positions of magnetometer runs;
- Trainees manually moved the magnetometer tow fish in runs from predetermined positions to search for shipwreck material and artefacts;
- Trainees executed a swim-line search to identify a magnetometer target off Dewatte Beach. They were required to work as a team in order to cover a large area of the sea bed. All trainees were successful in the completion of the task, which required visual accuracy, buoyancy control and the ability to navigate underwater.

*Trainee conservators with ceramic sherds*

Site L (the *Avondster*)
- Trainees assisted in the collection of wood samples and viewed on-site conservation.

**Student appraisal**

Trainees were assessed by each member of the team in five categories.

Assessment categories
1. Proficiency in water:
- preparation and planning
- ability to make decisions and complete a task underwater
- familiarity with equipment (scuba, hookah, compressor use etc.)
2. Recording:
- underwater measurements into site plans, check accuracy
- artefact drawing
- computing
3. Photography:
- underwater
- artefacts
4. Conservation issues:
- on-site conservation
5. Field notebooks
- detail and completeness
- accuracy

1. Proficiency in water

The trainees would all benefit from further diving experience. Most problems noted were related to diving technique which, in turn, effects their ability to execute a task underwater. Trainees should practice buoyancy control, paying special attention to keeping their fins off the bottom. They should also become more aware of diving safety, in particular ascent rates.

More work is required by all trainees in preparation and planning of a task. Too much time is wasted on site, discussing the task at hand. Trainees must undertake pre-dive planning.

All trainees have demonstrated competency in the water and show great promise with underwater work. It is recommended that they all participate in regular diving activities to improve diving technique.

2. Recording

Trainees showed teamwork skills in the collection and collation of information required for drawing a site plan. All contributed to producing site plans for particular sites by combining their various skills.

The artefact drawings were all undertaken with enthusiasm and patience, with some trainees excelling in their ability to capture not only the dimensions but a realistic image of an artefact. All will improve the quality of their drawings with practice.

All trainees were exposed to computer work including applications such as GIS. They were required to input data relating to their diving activities. Those with more experience in computer applications assisted the others, again demonstrating effective teamwork skills.

3. Photography

This topic was not considered assessable as the trainees had limited exposure to and use of equipment due to freight problems. All were present at several lectures and video presentations given by Pat Baker. These lectures served to give trainees a grounding in underwater photography. Trainees had some practical experience with the operation of video equipment, both on land and underwater.

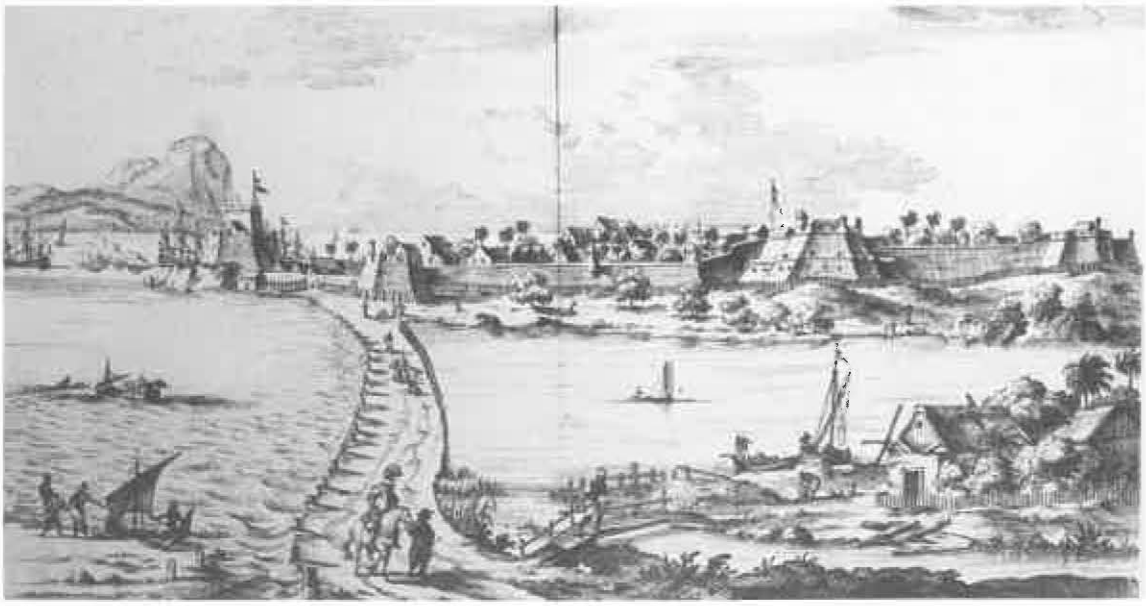
4. Conservation

This topic was not considered assessable as the trainees had limited exposure to and use of equipment due to freight problems. Jon Carpenter presented several lectures relating to on-site conservation. Students assisted conservators with the cleaning and other conservation practices associated with the stone anchors.

5. Field notebooks

The field notebooks all require more work. Most trainees need to record more information pertaining to their activities. The notebooks as they stand, record in brief, the day's events. Trainees need to expand their notes so that the notebook becomes a useful document to consult on maritime archaeology. Only two students diligently recorded enough information to make the notebook a useful tool in their continued studies.

Appendix: See: "Training Day Book Report"



*View of Galle by Baldeus (1672) showing N side of fortifications, and causeway to the Waterport. Note the boats in the right of picture indicate that Galle was on an island, also vessel in left middle could possibly be a wreck*

# CONCLUSIONS AND RECOMMENDATIONS

### Archaeology & history

### VOC sites

The Bay of Galle contains an unique collection of VOC wrecks, representing several types of ships in use by the Dutch during their presence in Sri Lanka (1640–1796). Because the wrecks can be linked directly with the administration of the company, records of which have survived in the archives of Colombo and in the Netherlands, the wrecks form a consistent source of information related to the shipping and trade during the 17th and 18th centuries. The combination of wreck archaeology and an archive, linked with the harbour and the shipping, provides an important opportunity for both a general study about trade and shipping, and a detailed study of the specific ships wrecked in the harbour.

On a methodological level, the VOC wrecks in the context of the harbour and the city of Galle offer interesting possibilities to relate history and archaeology. The presence of four or five identified and well-documented wrecks within this harbour offers the potential for a broad interdisciplinary study of the ships, the harbour, the city, and the organisation of the VOC. In a broader perspective, this case study can answer questions about the Asian shipping network and its organisation. Therefore, the Galle Harbour Project offers the chance to study VOC shipping in its Asian context. The ships discovered so far represent different aspects of the Dutch trade with Asia; being well-documented and from an important period, they can shed light on the function and activities of the harbour.

Roughly, such a study would be structured in four parts: the use of the harbour; local shipping and trade in the Gulf of Bengal; inter-Asia shipping and trade; and direct trade and shipping between Sri Lanka and Europe. Detailed questions may be asked about the following aspects:

- ship types in the inter-Asia trade and the trade between Asia and Europe; (both European and local vessels);
- technical development during the 17th and 18th centuries;
- organisation of the shipping in the harbour—repairs, equipment, crew, etc.

The harbour can not be isolated from the city and the region of which it formed a part. For that reason, co-operation has been established with other projects involved in the research and management of the cultural heritage in and around Galle. To support these Galle projects with practical information and to reveal detailed aspects of material history, a specific Archival Research Project has been suggested by Dr Lodewijk Wagenaar which would be related to the various aspects of the history of Galle.

He has studied, in the National Archives of Sri Lanka, the 18th-century documents from the VOC establishment of Galle—then the main port of Dutch maritime Sri Lanka. Most interesting, in his view, are the monthly reports written by the bosses of the several Galle departments, reporting on ship-repairing, house-building and maintenance, and upkeep of the fortifications. These monthly reports give day-to-day information about the work, the material used, and the labour involved. Based on these documents, a valuable overview of maintenance work can be extracted, to be used as historical information for two Galle projects: the Galle Harbour Project can be enriched with data about ship-repairing and the backgrounds of shipping logistics; the Galle Heritage Project, especially the pilot project 'Black Fort' (that aims to restore this oldest fort in Galle), can profit from the rich information on material used, labour involved and time spent, related to building and maintenance in the Dutch Period.

A small team of Dutch and Sri Lankan history students, under supervision of Dutch historians, Robert Parthesius and Lodewijk Wagenaar, and

*The archives played an important role in the identification of the Dutch wrecks. Both the VOC archives in Colombo and The Netherlands contain important information to understand the maritime practice in the Harbour of Galle. The information sent from the trading post in Asia to the directors of the VOC in the Netherlands was collected in the so-called 'Incoming documents from Asia'. Here the papers from 1760 containing reports from the harbour authorities of Galle. (Algemeen Rijksarchief VOC 2981)*

Sri Lankan expert on VOC archives K.D. Paranavitana, could work on these files, the so-called Galle Annual Compendia and their Annexes (related to the period 1740–1794), from late 1998. The result of this research, completed with relevant information from other documents in the VOC archives in Colombo as well as in The Hague, could be a Handbook. This would list materials, characteristics of crafts, etc., to be used as a guide for future restorations and reconstructions, in Galle itself as well as in other places with Dutch Period connections.

These archival sources are important and promising because of the actual impact on heritage policy, heritage plan implementation and execution. The Annual Compendia made by the Commander of Galle have been kept from 1740. From a monumentalist point of view, it might be attractive to concentrate on the last decades of the Dutch Period, because, not surprisingly, this stage of construction of the Dutch fortifications has been best preserved in the present Galle Fort. A concentration on the 1780s and early 1790s, therefore, seems attractive. However, to understand developments and combine research in ship-repairing, and building and fortification maintenance and construction, it might be wise to consider a longer period. Dependent on time and personnel, one could opt for one full year out of every five during the 1740s, 1750s, 1760s and 1770s.

Concurrent with this general research, investigations could be carried out around specific subjects like the history of a shipwreck or the background of a specific building in Galle.

Research of these kinds of sources for practical use in heritage policy is quite new. Therefore, it is very promising to know that the General State Archives in The Hague is also interested to act as a co-proposer to put this plan to the committee which advises on projects related with the new Dutch programmes of International Heritage.

The first product of this co-operation was a one-day seminar: *Galle—A Port City in History,* organised 15 November 1997 in Galle. One of the conclusions of the seminar was that only a combination of research and training would provide the basis for long-term preservation of the cultural heritage in Sri Lanka. To meet that goal, the following initiatives are developed for 1998.

**Field-school**

It is important to work as much as possible in co-operation: locally, nationally and internationally. In order to profit from each others' experiences and skills, and to avoid duplication of infrastructure, it has been suggested that a field-school should be established. The general philosophy is to have a co-ordinating centre for research, reporting, training and presentation activities. Such a field-school should be involved in a range of disciplines including maritime archaeology, heritage management, material conservation, historical research, etc.

Within the Galle Harbour Project, a field-school of this kind is evolving. An extensive programme of research and training has already been established. The Conservation Laboratory in Galle will be a permanent centre for further research and training in the conservation of maritime artefacts. After the 1997 expedition, we hope to have a team of diving researchers with the basic skills for maritime archaeology. To extend the programme to other areas of research and training, such as heritage management or restoration techniques to be used also for the other projects, we hope to set up a small education centre including a library, workshop room, and housing facilities for students and scholars.

A field school session of workshops for both the Galle Harbour Project and the Galle Heritage Project will be held in March–April 1998. During this session, students and scholars from various disciplines (maritime archaeology, history, conservation and heritage management) will be brought together to form a group that can carry out further projects.

During a session of the Galle Heritage field-school an international symposium called: *Past Meets Future, The World Heritage Site of Galle and Other Urban Heritage Centres: Towards a New Millennium,* will be held in Galle. During this symposium, we hope to start various pilot projects that will work on aspects of the Galle Harbour and Heritage Projects.

Presentation

Presentation is essential to disseminate the potential of the projects to an expert and general public. The field-school should serve as publisher of written reports and newsletters.

The Conservation Laboratory on the jetty near the old gate will show the maritime heritage to the general public. Through organised tours, visitors can see conservation work in progress and enjoy objects from the sea bed. The cleaning of the stone anchors next to the Maritime Museum has proved the public interest for opening up cultural awareness.

Special work groups at the field-school will concentrate, after conservation of objects, on cataloguing and investigation. The objects and the associated information should be moved to the Maritime Museum. A permanent display supplemented with temporary exhibitions will do justice to the maritime history of Galle and its role in the ancient trade routes.

A tempting idea is to set up a chain of presentations focusing on the maritime archaeological activities in the harbour. The starting-point would be the excavation. This is difficult since the work is executed underwater; nevertheless, techniques are available to give a glimpse of underwater archaeology to the public. The wreck of the VOC ship *Avondster* could provide such an opportunity to show an excavation to the public. The ship is in remarkably good condition up to the main deck. The wreck is in shallow water, only 50 m off Marine Drive. A simple jetty would allow the wreck to be accessed from the shore. The possibility of watching work in progress at archaeological sites elsewhere has proved to be popular and interesting for visitors. Local guides can activate interest by organising tours specially meant for cultural tourists

The Dutch invested heavily for their own profit in the 17th and 18th centuries. The heritage of this are ships and other monuments left behind as valuable assets for the community of Galle and for Sri Lanka. Cultural interest, scientific research outcomes, and commercial spin-offs can go hand-in-hand.

**Anchor site**

The recommendations for further archaeological work on the anchor site are dependent on the development and installation of a conservation management plan, thereby ensuring that these large artefacts are properly preserved. It is envisioned that the other stone anchors and the iron stock anchor be excavated after the completion of the Conservation Laboratory which would serve to preserve and house them upon raising. The timbers GHP 44 and GHP 45 will be treated at the Western Australian Maritime Museum and then returned to Sri Lanka. It is hoped that once conserved and after an appropriate display area in the Galle Maritime Museum has been established they will go on display alongside the stone shanks. A further examination of Sites P and T, as well as the surrounding area of Kamba Bandina Gala, is also required to establish if there are any more related artefacts. The area is littered with material, especially along the reef which runs through the site. A more thorough survey of this reef, and the material around it, may also shed more light on the context in which the stone anchors were found.

**Maritime archaeological training programme**

The most fundamental and potentially beneficial recommendation is for all students to participate in regular diving activities. This need not necessarily be archaeologically based, as recreational or sport diving would suffice. Accumulated in-water time will improve the trainees' dive techniques and allow the programme to concentrate on archaeological skills. Buoyancy, ascents and general proficiency to complete a task underwater will benefit from increased dive hours.

It may be more expedient to do this in a group over a few days; for example an extended three-day weekend, where trainees would undertake two dives each day. Reducing intervals between training seasons is strongly recommended since time is wasted in regaining the previously achieved level of proficiency.

To maximise the benefits of the training resources invested in the students, it is necessary to provide on-going exercises and projects throughout the year. A single, however intense, training programme of six weeks' duration every few years, is ineffective in producing workers able to undertake underwater archaeological work unsupervised. A framework of training objectives to cover a 2–3 year period would be ideal, in that regular contacts and on-going projects could be designed outside the field-work season.

The trainees achieved a great deal in 1997 and it would be advantageous to consolidate these skills before time reduces the impact of what they have learnt.

**Central store**

At present, each of the trainees are living and working some distance from each other. Maritime archaeology is not the main focus for the trainees who, although generally in the archaeology field are working in other areas. To encourage and foster their knowledge and interest, it would be advantageous to have a central, accessible location for the storage of equipment and training materials (books, survey equipment, etc.). This would allow all relevant material and resources to be accessed by the trainees in between field-work seasons. This initiative would also provide a central location to which maritime archaeological publications could be sent in, the knowledge that each of the trainees can access the information. Possibly, some system of loans of diving equipment could be organised to encourage trainees to gain more in-water experience. To combine this location with an interested co-ordinator would strengthen communication between the group, and assist with the planning of activities between field seasons.

**Conservation**

Conservation personnel

To expand the Sri Lankan conservators' contribution to the Galle Harbour Project, and to future work in this field, eligible (medically fit) persons should be taught to scuba dive. Initial training may require swimming lessons and techniques for survival in the water. This will be followed by snorkel-dive, then scuba-dive training. Diving conservators will be able to conduct environmental assessments of underwater sites, which are essential for establishing the longer term goal of a management programme for the underwater heritage of Sri Lanka.

**Future work recommendations**

In process:

- Complete the construction and fitting-out of the Conservation Laboratory.
- Complete construction of the large storage tank for the Arab-Indian anchor GHP 30.
- Monitor all stone anchors and ensure they are undergoing a period of soaking to remove salts, and that they do not dry out until salts have been removed (perform chloride analysis of solutions when chloridometer becomes available).
- Continue conservation treatment of artefacts recovered from the most recent and previous expeditions, including regular inspection to ensure no problems have developed with treated artefacts.

Proposed:

- Acquire or construct a range of large storage and treatment tank for artefacts (steel tank for treating large iron objects such as cannon and anchors).
- Carry out a more localised environmental assessment in the area of the anchorage site.
- Install sacrificial anodes on any *in situ* cast iron cannon and wrought iron anchors proposed for recovery.
- Perform an environmental assessment of the Galle Maritime Museum storage and exhibition areas.
- Introduce suitable conservators to scuba diving.
- Continue conservation practise and specific training with particular reference to operating the new laboratory.
- Dives could possibly be undertaken during the monsoons or immediately after the seasons, to assess the extent of sediment mobility on the most important archaeological sites.
- Samples of sediment to be collected from specific areas where the two rivers supposedly emptied into the bay in the past, for particle size distribution analyses to verify their position and, hence, the effect on the wreck sites in close proximity.
- Collect sediment and sea-water samples from the more archaeologically important or threatened wreck sites, for analysis of inorganic elements, size fractionation, organic materials, nutrient levels and the presence of pollutants.
- Acquire sediment pH profiles and redox potential measurements of the more archaeologically important or threatened wreck sites to ascertain the depth of mobile sediments, and to assist in determining the condition of *in-situ* artefact materials and suitable treatment for them.
- The acquisition of quantitative and qualitative on-site data of wreck sites in the Galle Harbour area should continue, to ensure that effective conservation management programmes are developed prior to excavation or protection of these shipwreck sites.

SITE E

- Conduct an extensive organic survey on the structural timbers above and below the sediment–sea-water interface. The measurements would include *in situ* pH profiles, percentage water contents and sampling, and identification of the timbers from specific positions on the wreck.
- Conduct an extensive electrochemical survey of the iron artefacts on the site, including depths of graphitisation and full analyses of the concretion and corrosion products.
- Analysis of the composition of the copper alloy fastenings, concretions and corrosion products. (The results of this conservation survey could be used as a comparative study with Site L.)

SITE F

- Continue the electrochemical survey of the cast iron cannon on the site.
- Conduct analysis of the composition of the cast iron cannon concretions, corrosion products and the residual metal.
- Select a cannon for possible recovery.

# APPENDICES

## Appendix 1. 1996 Conservation management report site L

Vicki Lewana Richards (research chemist) and Jon Carpenter (conservator)
Department of Materials Conservation, Western Australian Museum

### SITE L

*Location*

The wreck at Site L lies in the north-western end of Galle Harbour, about 50 m–100 m south of the rock shore-line, opposite the Galle market (see map on p. 14).

Dates of inspection: 4–9, 21, 25 March 1996

*Weather and sea conditions*

Generally fine and warm conditions with light winds, strength increasing by late afternoon. On a few days, there were overcast conditions accompanied by rain and stronger on-shore winds. Sea conditions were relatively calm with a swell height ranging between 0.5 m–1.5 m and a wave break on the rocky shore-line. There was a variable surge in the N–S direction, due to this shore break. Surge and swell usually increased by early afternoon. On some days, a slight current flowed in an easterly direction across the site. The underwater visibility varied between 0–5 m, dependent on the amount of suspended waterborne particulate matter disturbed by the surge and tide. The tidal range for Galle is 0.5 m; however, during the monsoon seasons, the harbour experiences rough conditions, sometimes accompanied by swells as high as 4.3 m (*West Coast of India Pilot* 1975). The NE monsoon extends from late October through to mid-November and the SW monsoon from late May to the first half of June. The frequency of cyclonic storms reaches a maximum during these two periods of the year. The water temperature at depth was 29°C. The average pH of the sea-water was $8.04 \pm 0.20$ and the average redox potential was $0.044 \pm 0.065$V. The dissolved oxygen content at depth was 5.9 ppm (78% of air-saturated water) and on the surface was 6.8 ppm (89% of air-saturated water). The salinity was 32.9 ppt at 29°C which was corrected for temperature and calculated at 26.3 ppt at 20°C. The average salinity of open sea-water is 35 ppt, but coastal waters and tidal-influenced harbours usually possess lower salinity than the open ocean.

*Description*

General

The partially buried wreck lies on a gently shelving sea bed composed of sand and finer sediment, covered with organic detritus. The sediment affected visibility significantly when disturbed by water movement. The water depth over the site ranged from 2 m–4 m. There are no reefs in close proximity.

*Flora and fauna assemblages*

During the previous inspection of Site L, conducted in February 1993, marine life was reported as being generally limited with only a single lionfish noted. During the March 1996 survey, a variety of fish species were observed. As had been previously noted, stinging hydroids were abundant, both the white feather-like species and the brown algae-like form.

*Fresh water influence*

As a consequence of different densities, a noticeable layer of fresh water was present on the sea surface following heavy rain during the 1996 expedition. During the monsoon seasons, fresh water would flow directly into the harbour from drains in close proximity to the site. The lower salinity of the harbour (26 ppt) denotes decreased concentrations of dissolved salts in the sea-water due to the influx of fresh water. The presence of fresh water will directly affect biological activity and the degradative processes occurring on-site. In addition, based on archaeological evidence, the vessel remains at Site L are believed to date from the mid-17th century. At this time, two rivers flowed directly into the Bay of Galle. This fresh-water influence from such a large source would have decreased the overall degradation rate on the site during this time period. It is important to note that the rivers, that were near the wreck site, no longer flow in this area.

*Human disturbance*

There was no obvious evidence of human disturbance on this site. However, because the site is readily accessible from the sea and the land, it is assumed that heavy salvaging of exposed artefacts may have occurred over the years. The close proximity of the wreck to the town of Galle has resulted in contamination of the site with modern materials, such as paper, newsprint, clothing fragments, animal remains and other rubbish. No evidence was apparent to suggest that the presence of these materials had affected the site environment. Such contamination, however, may attract scavengers and provide a food source for bacteria which, in turn, may degrade organic wreck materials. It was noted that clothing and other materials had become trapped around the wooden stock of the partly exposed anchor. It is likely that this, in conjunction with water movement, has contributed to the damage incurred since the last site inspection.

Galle Harbour has extensive naval and urban developments on its coast-line. The harbour acts as a port and a base for professional fishing operations. Disposal of effluents may have led to the pollution of the surface sediments in the harbour. Pollution will directly affect biological activity and the growth rate of fouling assemblages, which are important in shipwreck deterioration.

*Wreck*

*General observations*

The remains of the vessel lie parallel to the shore-line in a north-east–south-west orientation at a depth of approximately 3–4 m, covering an area about 40 m long and 10 m wide (see plan on p. 25). The bow lies towards the south-west and the stern in a north-easterly direction. The wreck consists of an outline of timber frames and planking averaging about 500 mm above the sea bed. The vessel's timbers are exposed at the bow end, and about mid-site the perimeter of the vessel becomes buried in sand. After a short distance, the timbers are uncovered again for a few metres then become completely buried until a relatively extensive section of the stern is reached. The stern protrudes approximately 2–2.5 m above the sediment. The centre section of the site is almost entirely covered with sand. In two places along the inner port side, a deck support timber protrudes from the central sand mound. A large (5.0 m by 1.5 m) assemblage of bricks (*overijselsteen*), cemented together, lay partly exposed in the centre of the site. Lead sheet protrudes from the sand nearby and was proven, following excavation, to be associated with the brick mass. On the shoreward side of the site, near the bow, a large wrought iron anchor shank, on the remains of its wooden stock, rises from the sand and terminates in a complete anchor ring, 3 m from the water surface. There is only a light covering of sand around a matrix of concretions inside the bow region. Iron concretions extend from the starboard side of the bow region and continue to where the timbers first become buried. Four concreted iron cannon were located, all positioned on the starboard side of the vessel.

*Degree of site exposure*

The site averages some 500 mm above the sea bed. The maximum height of exposure is the recently located external port side stern section which rises 2.0–2.5 m above the sediment. The bow region is exposed to a height of about 1.0 m. Overall, the highest part of the site appears to be the ring on the end of the anchor shank which is about 3.0 m from the water surface. The perimeter of the vessel is heavily scoured, with the shoreward face of each side of the timbers being more exposed than the seaward-facing side.

*Evidence of Seasonal Exposure*

The extent of site exposure is similar to that reported in 1993 [Carpenter & Richards, 1993; Green *et al.*, 1992], the exception being the stern section which was not described in the previous reports. This suggests that this section was not located in the previous surveys, due to poor visibility or because it was totally buried. The outer surface of the stern section was covered in a layer of anaerobic concretion formed by the corrosion of iron sheathing nails that secured the sacrificial planking. This may indicate that the stern was buried rather than not located during the previous surveys.

Other exposed structural features were relatively free of marine concretions and algal growth. Generally, the excellent condition of the timbers and the apparently limited damage by marine worms indicates that this site is buried for extended periods of time. The timbers examined on the seaward side of the vessel appear to be less degraded than those on the shoreward side. The comparative increase in degradation of the in-shore timbers would probably be due to the abrasive movement of water and sand across the site. As the ocean swell traverses the site, the surge causes scouring of the shoreward facing timbers and deposition of the sediment on the opposite face.

During the 1993 survey, one-half of the wooden anchor stock was exposed, and despite some penetration by teredo, the stock appeared well preserved and still resilient. In this 1996 survey, the surviving portion of the stock had lost more than half its length. The fact that the stock had survived at all would indicate that the site was extensively buried for many years, and it was only recently exposed for this marked deterioration to occur. The extent of damage that has occurred to the stock over the past three years suggests that it may disappear entirely in the near future.

The two totally exposed cannon are concreted and appear to have suffered erosion from excessive sand and water movement. The concretion which has formed in this case is the typical aerobic encrustation that encapsulates other exposed cannon located in the Galle Harbour area. This observation suggests the cannon were buried only for a short period or were never buried. The two partially exposed cannon were covered in the typical anaerobic concretion, which is thin but very hard and dense, indicating that they had been mostly buried by sediment for extended periods of time.

Excavation carried out around the brick assemblage and extending to the starboard side of the vessel revealed sediments with the typical black discoloration, indicating an anaerobic environment at a depth of about 100–300 mm. This implies that the depth to stable sediment is, on average, approximately 200 mm.

*Evidence of human disturbance*

No evidence of human interference was found, but it is common knowledge that local divers salvage material from wrecks. Indirectly, the close proximity of the wreck to the town of Galle has resulted in contamination of the site by modern and unrelated materials.

*Exposed artefacts*

Iron

All iron material is covered in concretion. Many ring and bar shapes are discernible in the concretions on the starboard side of the site. The two exposed, eroded cannon were covered with aerobic concretion and secondary marine growth, such as barnacles, etc. The partially buried cannon were encapsulated in the typical thin, hard and dense anaerobic concretion. The mouldings and other features of these cannon were easily discerned. The wrought iron anchor was also covered in a thin layer of concretion. Corrosion potentials and surface pH values of some of the iron artefacts were measured, and the results are presented in Table 1.

*Table 1. Corrosion potentials and pH values of metal artefacts measured on Site L.*

| Description of Materials | d(mm) | pH | Corrosion Potentials (rel. NHE) (V) |
|---|---|---|---|
| **Ferrous Materials** | | | |
| wrought iron anchor shank | 15 | 5.45 | -0.258 |
| wrought iron anchor ring | 5 | 7.41 | -0.255 |
| exposed cannon | 5 | 6.62 | -0.137 |
| partially buried cannon | 10 | 5.91 | -0.259 |
| iron concretion starboard side | 20 | 6.09 | -0.186 |
| iron block near bow | - | 7.13 | -0.029 |
| **Lead Materials** | | | |
| lead sheet near bricks port side | - | 7.95 | -0.122 |

Lead
The lead sheet discovered near the brick mass possessed a coherent black corrosion product layer, indicating the lead had been subject to a primarily deoxygenated marine environment. The voltage and the surface pH were measured and are presented in Table 1.

Bricks
The bricks were lightly covered with marine growth and were in sound condition. Samples of the bricks and mortar were collected for inorganic analysis.
Ceramics and Glass
Two beardman jugs were recovered from the site after some limited excavation near the brick mass. Both were broken *in situ* and, as a consequence, some pieces were missing. Some clay pipe bowls were recovered. The ceramics were in good condition; however, some possessed the usual black discoloration, indicating the presence of sulphides in the sediment.

*Organic survey*
Wood
Generally, the exposed structural timbers on Site L appeared to be in good condition. Marine borer attack was apparent in the timbers examined, but was not extensive. This is indicative of periodic exposure and reburial cycles occurring on the wreck site. The exposed timbers on the seaward side of the vessel's perimeter appeared less degraded than those on the shoreward side. The comparative softness of the in-shore timbers would be due to differences in the physico-chemical micro-environments between both sides of the vessel. The vessel is clearly sheathed in thin softwood boards secured with iron fastenings. Between the sacrificial boards and the planking, animal hair is present, impregnated with a brown-black organic substance. In conjunction with protection afforded by burial, it appears that these original measures taken to protect the vessel from destructive marine organisms have provided continued protection to the exposed timbers of the shipwreck.

Some timber samples were collected from this site in 1993 for wood identification and maximum water contents ($U_{max}$) (Godfrey, 1993). Some of the results are outlined below (Table 2).

*Table 2. Wood identification and $U_{max}$ values for wood samples collected from Site L in 1993 (Godfrey, 1993).*

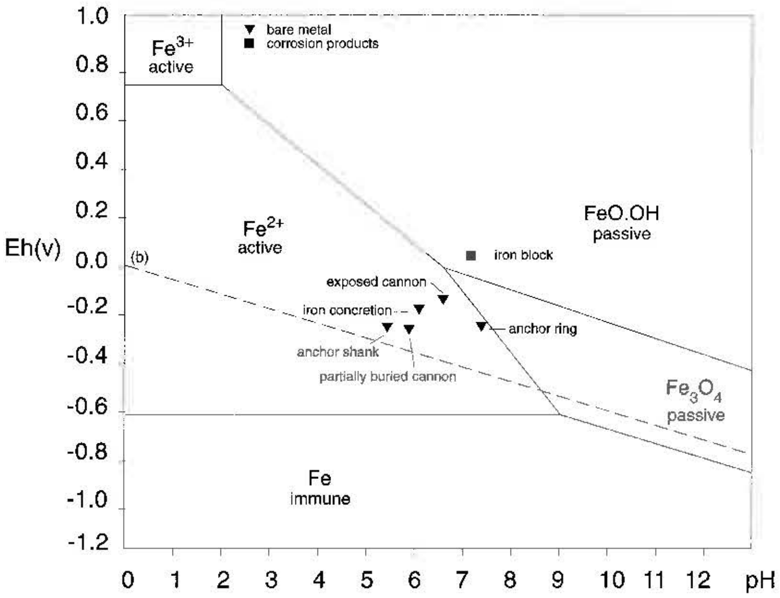
| Sample Description | Umax (%) | Identification |
|---|---|---|
| frame | 75 | white oak |
| outer skin | 240 | maple |
| inner planking | 150 | pine of the red deal type |
| anchor stock | 165 | *Anisoptera sp* |
| tree nail | 510 | white oak |

In the 1996 survey, *in situ* pH profiles of selected aerobic and anaerobic structural timbers were obtained. Samples of these measured timbers were collected for wood identification and maximum water content ($U_{max}$) analyses. Some of the results are outlined below in Table 3. The complete report by I.M. Godfrey, identifying the wood species, is pending.

*Table 3. Wood identification and $U_{max}$ for wood samples collected from Site L in 1996.*

| Sample Description | Umax (%) | Identification |
|---|---|---|
| frame | 113±22 | white oak |
| frame | 119±10 | n.d.1 |
| inner planking (matting both sides) | 150±18 | European or common elm |
| outer planking (bow) | 242±36 | pending |
| inner planking (bow) | 176±12 | European or common elm |
| outer planking (midships, starboard, shoreward) | 244±4 | pine of the red deal type |
| outer planking (midships, starboard, seaward) | 492±82 | n.d. |
| inner planking (midships, starboard, seaward) | 264±8 | white oak |
| outer planking (stern, port, NE, seaward) | 100±11 | pine of the red deal type |
| outer planking (stern, port, SW, seaward) | 130±28 | pine of the red deal type |
| inner planking 1 (stern, port, SW, shoreward) | 508±85 | n.d. |
| inner planking 2 (stern, port, SW, shoreward) | 500±34 | n.d. |
| inner planking 3 (stern, port, SW, shoreward) | 130±1 | white oak |
| inner planking (stern, port, SW, on flat) | 278±6 | n.d. |
| planking (galley) | 560±51 | pending |
| anchor stock | 116 | n.d. |
| sample unknown | n.d. | pending |
| 1 not determined | | |

Matting
A sample of matting found between the sacrificial and inner planking was collected for microscopic fibre analysis. The matting has been analysed by Fourier transform infra-red (FT-IR) spectrometry (Fletcher, 1997a). The resinous material impregnating the animal hair will be analysed by FT-IR spectrometry and nuclear magnetic resonance (NMR) spectroscopy. In 1993, a sample of the organic substance was extracted and analysed by NMR and the spectrum was characteristic of that expected for retorted




*Pourbaix diagram for iron ($10^{-6}$M) in aerobic sea water at 25°C indicating the state of the iron objects on Site L.*

pine resin (Godfrey, 1993); however, no positive identification was made at that time. The results of the fibre identification and the characterisation of the resinous material collected in 1996 have not been received as yet.

Sediment

Sediment samples were collected on the north-east side of the brick assemblage during excavation procedures. Samples were collected at the sediment surface and at depths of 1 m and 2 m. Redox potentials and pH values were not obtained. The sediment samples were analysed for inorganic elements, size fractionation and organic materials. Samples of the sea-water from the surface, the sediment and sea-water interface, and pore water samples extracted from the sediment samples were also collected and analysed for basic and major ions and nutrient levels. In addition, the sea-water was analysed for heavy metals.

*Interpretation of results*

Iron

All iron artefacts exposed to the oxidising marine environment of Site L were covered with concretion. The depth of concretion on the wrought iron anchor shank and ring was 15 mm and 5 mm, respectively. The depth of graphitisation of the exposed cast iron cannon was 5 mm and of the partially buried cannon was 10 mm. In addition, the depth of graphitisation of the cast iron concretion, measured on the starboard side of the site, was 20 mm. Therefore, the average depth of graphitisation is about 12 mm. Iron is not biologically toxic and assists in increasing the growth rate of encrusting organisms. In tropical environments, the rate of formation of aerobic concretions is relatively fast. The concretion acts as a semi-permeable membrane on the surface of the iron, effectively separating the anodic and cathodic sites. This produces an acidic, iron and chloride-rich micro-environment at the residual iron surface. The measured voltages and corresponding surface pH values were plotted on the Pourbaix diagram for iron in aerobic sea-water above.

The points on the Pourbaix diagram indicate that all iron objects are actively corroding with the exception of the iron block that was located inside the bow area, which lies in the passive FeO.OH region. Iron oxy hydroxide (FeO.OH) is one of the major components of aerobic iron concretions. Potentials in this area are essentially redox couples measuring the ratio of $Fe^{3+}$ to $Fe^{2+}$ ions and are typical of iron artefacts where no solid metal remains underneath the concretion. Under these conditions, there is no longer the driving-force to maintain the lower pH and $E_h$ values inside the concretion and the solution slowly equilibrates to those values of the local environment.

Cast iron typically contains 2–6% carbon by weight, and the more positive corrosion potentials for the exposed cast iron is a reflection of the enobling effect of the carbon. Cast iron consists of various phases of metallic iron which are corroded at appreciably different rates. The order of dissolution, fastest to slowest, for the different phases is ferrite (essentially pure iron), pearlite (a combination of ferrite and cementite), cementite ($Fe_3C$) and graphite. The major phase in wrought iron is ferrite with strips of slag incorporated into the structure during the manufacturing process. The difference in corrosion potentials for the oxidation of cementite versus iron to ferrous ions is 50 mV, which is very similar to the difference in the corrosion potentials of the wrought iron anchor and the exposed cast iron on this site.

During corrosion, the iron containing phases of cast iron are corroded, but the graphite remains as a three-dimensional network which retains the original shape, size and surface details. In addition to the graphite, silica and iron minerals such as FeO.OH, $Fe_3O_4$ and FeOCl are often present in the corrosion product layers of cast iron. However, this mixture is very fragile and unstable and these iron objects need to be treated with extreme care so no archaeological information is lost. The corrosion of wrought iron does not leave a coherent residue, but the same iron minerals are present in the corrosion product layers.

The corrosion potential and the surface pH of the exposed cast iron cannon were higher than those of the partially buried cannon. The more negative potential of the buried cannon reflects a slower corrosion rate for this cannon. The decrease in the corrosion rate would be due to the fact that this cannon is mostly buried and this lowers the dissolved oxygen flux to the corroding iron surface. Physical abrasion by sand and water movement will also be diminished.

It has been suggested by the archaeologists and historians that this wreck is possibly a mid-17$^{th}$-century VOC vessel—the *Avondster* (1659). If this is correct, then this wreck has been submerged for about 337 years. Therefore, using the average depth of graphitisation of 12 mm, the mean corrosion rate for cast iron exposed on this site was calculated at 0.035 $mmy^{-1}$. This is approximately one-third the standard corrosion rate for isolated iron in aerobic sea-water (0.1 $mmy^{-1}$). The decrease in the overall corrosion rate could be due to a number of different and interrelated factors. Measurements of dissolved oxygen in the sea-water does not change significantly with water depth;

therefore, the decrease in the mean corrosion rate cannot be directly due to the dissolved oxygen levels. Since corrosion rates are largely determined by the dissolved oxygen flux, extensive burial of the site will decrease the flux of dissolved oxygen to the iron objects which will, in turn, lower the mean corrosion rate.

The temperature, salinity and dissolved oxygen concentration of the sea-water was constant over the survey period of this wreck site. These measurements can then be used to calculate the relationship between the corrosion rates and the $E_{corr}$ values recorded for the cast iron objects on this site from equation 1 (MacLeod, 1995), where the concentration of dissolved oxygen is recorded in $cm^3dm^{-3}$.

$\log d_g/E_{corr} = 10.33 \log[O_2]–4.57$ (1)

From this equation the 'slope' or dependence on $E_{corr}$ was calculated at $2.15V^{-1}$. Since the mean corrosion rate and the $E_{corr}$ of the cast iron objects are known, the value of the constant in equation 2 can be calculated.

$\log d_g = 2.15\ E_{corr} + \text{constant}$ (2)

The constant was -1.039. Therefore, the iron corrosion equation for Site L is

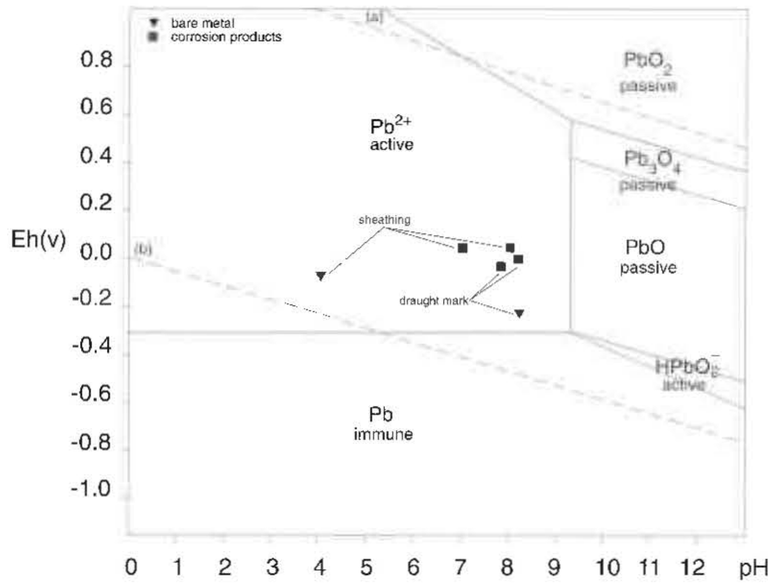
$\log d_g = 2.15\ E_{corr}–1.039$ (3)

The Tafel slope is equal to the reciprocal of the slope which is 465 mV. Because of the high temperature and, therefore, the low concentration of dissolved oxygen on Site L, it takes a change of 465mV to bring about a tenfold increase in the corrosion rate. If there has been a change of 2 mV in corrosion potential, then it is possible to state that a change in corrosion rate has occurred and therefore, in the condition of the artefact. The percentage change associated with a 3 mV shift in corrosion potential of cast iron on Site L is 1.5%. On the average Australian shipwreck site, it takes only 328 mV to bring about a tenfold increase in the corrosion rate and a 3 mV shift in corrosion potential equates to a 2.1% change. Therefore, if the assumption of the vessel's age is correct then the corrosion monitoring parameters indicate that the rate of corrosion for artefacts on Site L is considerably less than the average corrosion rate on the average Australian shipwreck site. The lower corrosion rate on Site L would be mainly due to the higher water temperature, the low dissolved oxygen levels and salinity, and the fact that the vessel has been mostly buried for a considerable period of time.

Lead

The surface pH and corrosion potential of the lead sheet was plotted on the Pourbaix diagram for lead in aerobic sea-water (see above)

The lead sheet was in good condition, considering it was in the zone of active corrosion. The main lead corrosion products found on lead subjected to marine environments are angelsite ($PbSO_4$) and laurionite ($Pb(OH)Cl$). The range of pH and redox potential where these minerals are thermodynamically stable is not shown on this Pourbaix diagram. However, the lead was covered with a thin layer of concretion-corrosion product layer about 1–2 mm thick. This would generally be composed of sea bed debris and angelsite held together with calcite ($CaCO_3$). There were no secondary marine growths due to the higher toxicity of lead and its corrosion products to marine biota in tropical waters. The formation of angelsite forms a passivating surface film and protects the underlying metal, and produces a marked rise in the corrosion potential of the lead which is evident from the Pourbaix diagram.




*Pourbaix diagram for lead ($10^{-6}M$) in aerobic sea water at 25°C indicating the state of the lead sheet on Site L.*

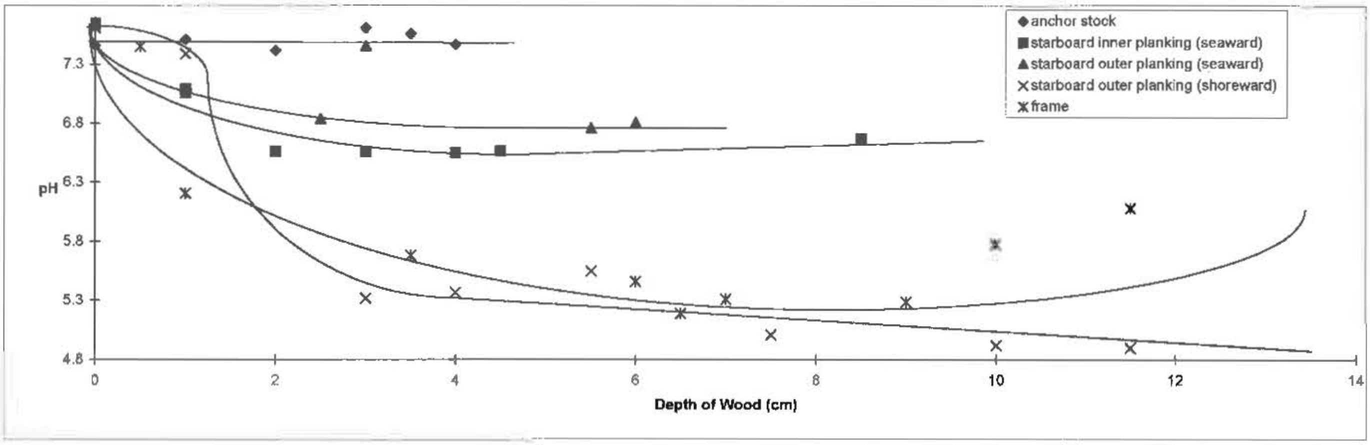
Bricks

The inorganic analysis of the brick and mortar recovered from the brick assemblage was performed at the Materials Institute (WA) and paid for by the Department of Materials Conservation of the Western Australian Museum. The brick was mainly composed of quartz ($SiO_2$) with some augite (a common silicate) and feldspar. Aragonite (orthorhombic $CaCO_3$) was identified as needles in the cavities of the sample. This suggests this mineral was precipitated from evaporation of the sea-water in the brick on air drying (Fletcher, 1997b).

The mortar sample was mainly composed of quartz grains cemented with calcite ($CaCO_3$). Other minor minerals present were feldspar, clay and pyrite (FeS). The pyrite may be present as a contaminant which may have precipitated under the anaerobic conditions present in the sediment. Tin was also detected as another probable contaminant. The mix ratio of the mortar was found to be 1.4 parts sand to 1 part lime [$Ca(OH)_2$]. Other tests showed that not all calcium had been converted and was present in the form of $CaCO_3$ but a substantial amount was still in the form of $Ca(OH)_2$ (Fletcher, 1997b).

Wood

In general, the wooden structural timbers on Site L are extremely well preserved because the site has been previously buried under the sediment for a long period of time and has only recently been uncovered. Interestingly, some areas of the wreck appeared more




*pH profiles of aerobic structural timbers and anchor stock measured on the starboard side of Site L.*

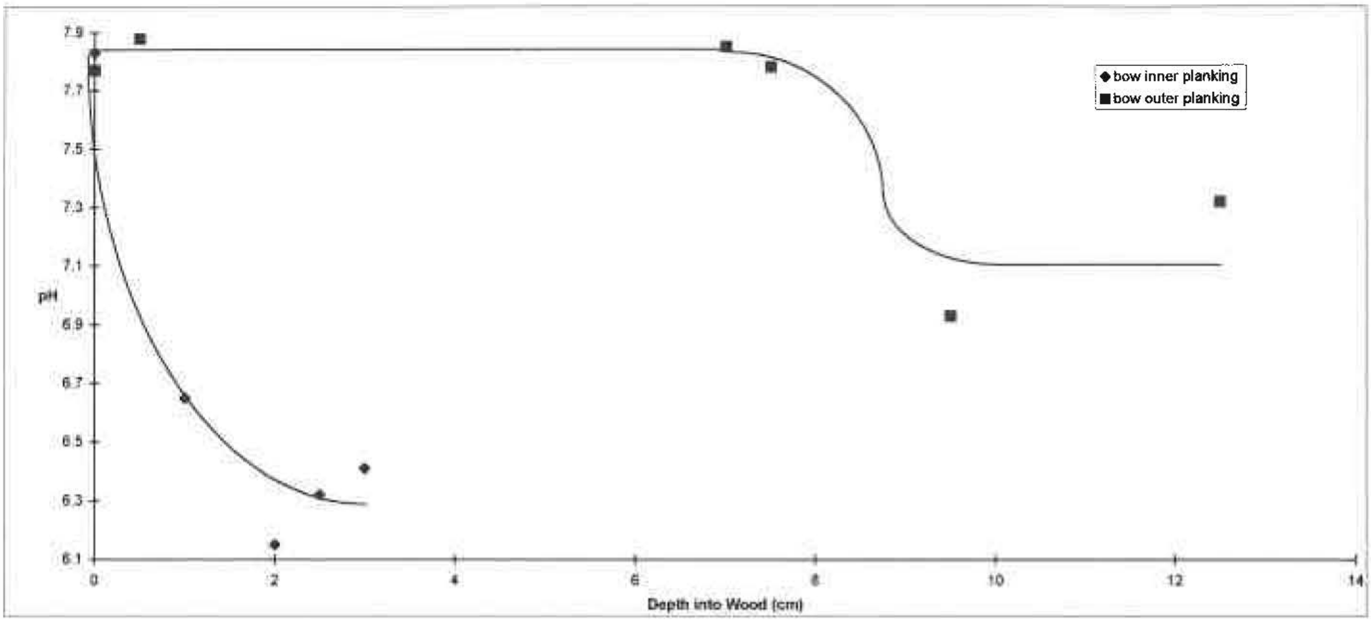
degraded than others. This would be due to the differences in the local micro-environments on-site. There is some marine worm attack, but it is not excessive. Biological, chemical and physical degradation of wood occurs, to some extent, on all shipwreck sites; however, it is proposed that physical and, to a lesser extent, biodeterioration are the major mechanisms causing the *in-situ* degradation of this wooden vessel.

From the microscopic analysis, the samples of outer planking were identified as a pine of the red deal type; the samples of the inner planking as a European or common elm; the frames as white oak; and the anchor stock as a tropical wood species native to Asia (Godfrey, 1993). The pH profiles of some aerobic structural timbers and the exposed anchor stock, located on the starboard side of the site, are shown in the figure above

From observing the pH profiles of the inner and outer planking and the timber frame, in general, the plots of pH versus core depth follow a typical sigmoidal relationship; i.e., the pH of the wood near the surface is high, then as the core depth into the timber increases there is a sharp and rapid decrease in pH, which tends to plateau with increasing core depth. The higher pH measured on the wood surface, slightly more acidic than sea-water, is indicative of the pH being controlled by the buffering capacity of the sea-water. More importantly, this maximum pH denotes the area of greatest deterioration. As wood degrades in a marine environment by physical, chemical and biological means, its polysaccharide content is reduced, and spaces created within the wood structure are then filled with alkaline sea-water. This initially occurs in the outer, more exposed areas of the timber. Hence, the normally acidic nature of the wood becomes progressively more alkaline with increasing degradation due to the inward diffusion of sea-water. The pH then rapidly decreases as the depth increases into the wood core, indicating a gradual decrease in the extent of degradation. The pH will reach a minimum, denoting the area of least deterioration, where the wood is less waterlogged. The overall decrease in the pH of the wood core is an indication of the inherent acidity of the wood. The innermost wood is still waterlogged, albeit to a lesser extent than the outer surfaces; therefore, the pH will be more alkaline than the standard pH of seasoned, modern, undegraded wood of the same species.

On the starboard side of the vessel, the inner planking is about 80 mm wide and the outer planking is approximately 160 mm wide. Plots of pH versus core depth may be used to approximate the width of structural timbers that are difficult to measure physically. The pH profiles of the planking support the physical measurements. In addition, the planking is relatively degraded on the surface to a depth of approximately 20–30 mm. This would seem to indicate that these timbers have been exposed to the aerobic marine environment for some time. However, the pH values of the inner ($U_{max}$ = 264) and outer planking on the seaward side ($U_{max}$ = 492) of the site were higher than those values measured for the in-shore outer planking ($U_{max}$ = 244). This seems to indicate that the timber on the seaward side is more degraded than the shoreward timber. This conclusion is supported by the $U_{max}$ data. The increase in the extent of degradation of the seaward timber may be due to the surge moving across the site, towards the beach and rock wall, increasing water and sand impingement and increasing the rate of deterioration of wood on this side of the vessel. As a consequence of the surge, sand appears to be deposited on the shoreward side of the vessel in this position, which would provide the wood with some protection from degradation. Overall, the pH profiles and $U_{max}$ of the planking indicate a heavily degraded outer layer surrounding a partially degraded inner core.

The frames were approximately 200 mm thick. The frame investigated showed the typical pH profile for white oak, degrading in an aerobic marine environment. The pH of the frame surface was high, indicating the area of greatest deterioration. As the core depth increased, the pH correspondingly decreased until a plateau was reached at a minimum pH value, which denotes the least degraded area of the timber. Then, as the depth into the wood continued to increase, there was a turning-point and the pH began to increase again, indicating a gradual increase in the extent of wood degradation as the opposite side of the timber was approached. The pH profile and a maximum water content of 113% indicates that this frame possesses a degraded outer layer approximately 1 cm thick, with a




*pH profiles of aerobic bow planking measured on Site L.*

solid wood core, and it is in excellent condition.

The pH profile of the anchor stock did not follow the typical sigmoidal trend. The average pH of the timber was 7.50 ±0.07 to a depth of 40 mm after which the timber was too hard to penetrate with the drill bit indicating essentially undegraded wood. The $U_{max}$ of the anchor stock was 116%. This timber seems to possess a degraded outer layer (40 mm) surrounding a solid wood core and is in relatively good condition.

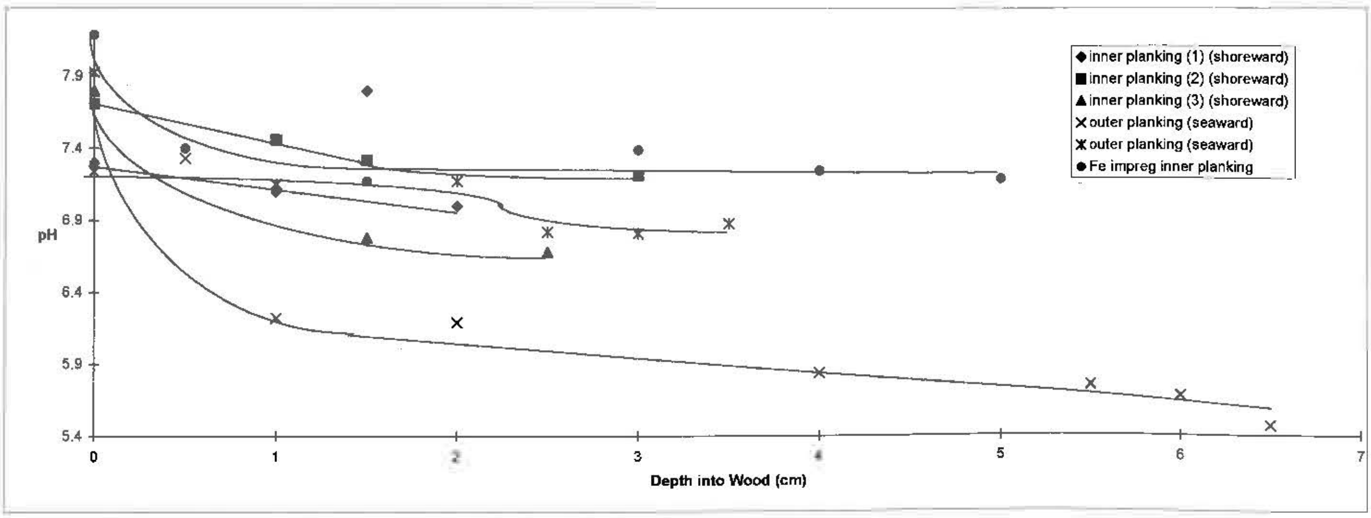
The pH profiles of some exposed inner and outer planking, located at the bow of the vessel, are shown above.

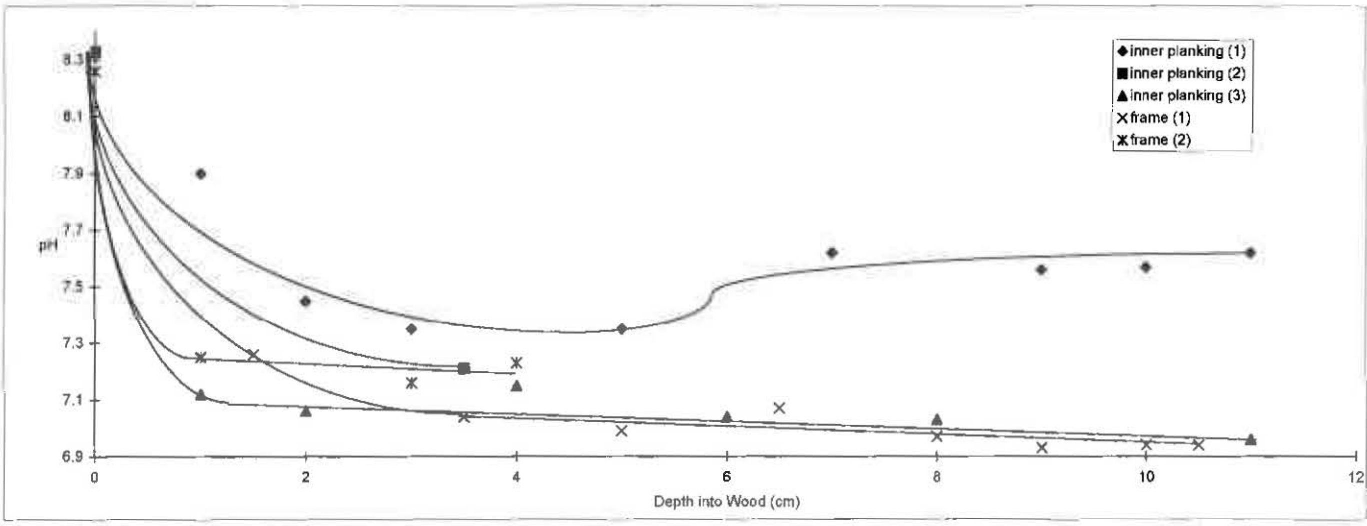
The pH profile of the inner planking shows a high surface pH, indicating a thin, heavily deteriorated surface layer. The pH then rapidly decreases as the depth increases into the wood core, indicating a gradual decrease in the extent of degradation. The pH reaches a minimum at about 20–30 mm and this indicates the area of least deterioration, where the wood is least waterlogged. This profile indicates that the surface of the inner planking is degraded; however, the inner region is relatively undegraded. In contrast, the pH profile of the outer planking indicates the timber has a highly degraded surface layer of 70 mm, surrounding a slightly less deteriorated inner region. Therefore, in comparing these two profiles, it is obvious that the extent of degradation of the outer planking ($U_{max}$ = 242) of the bow is much greater than the inner planking ($U_{max}$ = 176). This would not be unexpected as the outer planking is extremely exposed to the ravages of water and sand movement, and there is a deep scour around this area. The inner planking is more protected by partial burial in sand and the outer perimeter of the vessel.

The pH profiles of some exposed inner and outer planking of the stern section measured on the port side of the vessel are shown below.

From observing the pH profiles of these aerobic timbers, in general, the plots of pH versus core depth follow the typical sigmoidal relationship of wood degraded in aerobic marine environments. Hence, the same explanation for the decrease in pH from the outer surfaces to the inner regions of the wood described previously, will apply to these aerobic timbers. The

*pH profiles of aerobic inner and outer planking of the stern section measured on Site L.*






*pH profiles of aerobic inner planking and frames measured on Site L.*

surface layers of the planking have the normal high pH which represents the area of greatest degradation. As the core depth increases, there is a gradual decrease in pH indicating partial deterioration, which then plateaus at a minimum pH denoting the area of least degradation. The extent of degradation of the timbers on the shoreward side of the stern section ($U_{max}$ = 508, 500, 130) is greater than those on the seaward side ($U_{max}$ = 100, 130). The planking on the seaward side of the stern section is covered in concretion from the corrosion of the iron fastenings used to secure the sacrificial planking, and this would have preserved the wood to a large extent. However, the planking thickness ranged from 20 mm to 70 mm, indicating varying degrees of physical degradation. The more exposed timbers were thinner and, therefore, suffered greater deterioration. Only the outer planking on the seaward side of the large stern section ($U_{max}$ = 100), which rose 2 m from the sediment, was in relatively good condition.

The outer planking on the seaward side of the large stern section plateaus at a much lower pH value than the other planking, which indicates that this outer plank is much less degraded than the other timbers. This would be due to the fact that this timber was covered in anaerobic concretion, formed from the corrosion of the iron fastenings used to secure the sacrificial planking. However, it has been suggested that, in the past, this section of the hull was covered in sediment and has only recently been exposed. The concretion and the previous burial in the sand would protect the timber by decreasing the physical, chemical and biological deterioration of the wood.

The pH profiles of anaerobic inner planking and frames measured on the port side of Site L are shown above.

These timbers were uncovered during the dredging operations of a small discrete area north-west of the brick mass. The pH profiles of these anaerobic timbers followed the same basic trend as the aerobic timbers measured on this site. Therefore, the same explanation for the decrease in pH from the outer surfaces to the inner regions of the wood will apply to these excavated, anaerobic timbers. The inner planking (1) and (2) were more degraded than the other structural timbers. These timbers were very close to the sediment surface and, therefore, would be easily exposed during periods of excessive water movement. On the other hand, inner planking (3) and the two white oak frames were buried deeper and are in excellent condition. It is well known that wood recovered from de-oxygenated environments is usually well preserved because the wood is predominantly protected from extensive physical and biological deterioration. The surfaces of the timbers are degraded, but most of this deterioration would have occurred before the wreck remains were buried; however, biological deterioration of the wood surface may continue under anaerobic conditions due to the presence of sulphate-reducing bacteria, which utilise the wood as a nutrient source.

In general, interpretation of the pH profiles indicates that the exposed timbers on Site L are in relatively good condition considering the exposure to the dynamic, aerobic marine environment in Galle Harbour. Basically, as the aerobic timbers are traversed from the exposed surfaces to the interior regions, the profiles indicate there is a degraded outer surface layer, varying in depth depending on the position on-site, progressing to an area of partial degradation which, finally, reaches a relatively undegraded inner core. The condition of the exposed timbers may be attributed to the site being only recently exposed. As would be expected, the anaerobic timbers are in an excellent state of preservation.

Sediment

The sediment analyses were performed by the Chemistry Centre (WA) and paid for by the Department of Materials Conservation of the Western Australian Museum. The raw data and some recommendations are presented in the report written by McGuire and Schulz (1997).

The sediment on Site L, to a depth of approximately 100 mm, was essentially sterile with respect to artefact material. The results of the size fractionation analysis of the sediment samples are presented in Table 4, reproduced directly from the Chemistry Centre report

(McGuire & Schulz, 1997).

*Table 4. Screen analysis of sediment samples collected from Site L*

| Sample | Very Coarse Sand (%) (+1 mm) | Coarse Sand (%) (+600 µ) | Coarse to Medium Sand (%) (+150µ) | Very Fine Sand to Coarse Silt (%) (+38µ) | Coarse Silt to Clay (%) (-38µ) |
|---|---|---|---|---|---|
| Surface Sample(0 m) | 4.1 | 1.7 | 32.2 | 61.8 | 0.1 |
| Depth (1 m) | 24.9 | 19.2 | 34.1 | 21.6 | 0.3 |
| Depth (2 m) | 25.5 | 16.1 | 39.5 | 18.1 | 0.8 |

The simplest method of presenting this data is in graphical form by means of a histogram (see below). Trends in the frequencies of individual size grains may be seen at a glance, and it is especially effective for the identification of primary and secondary modes (most common grain sizes) and their intervening saddles (Buller & McManus, 1979).

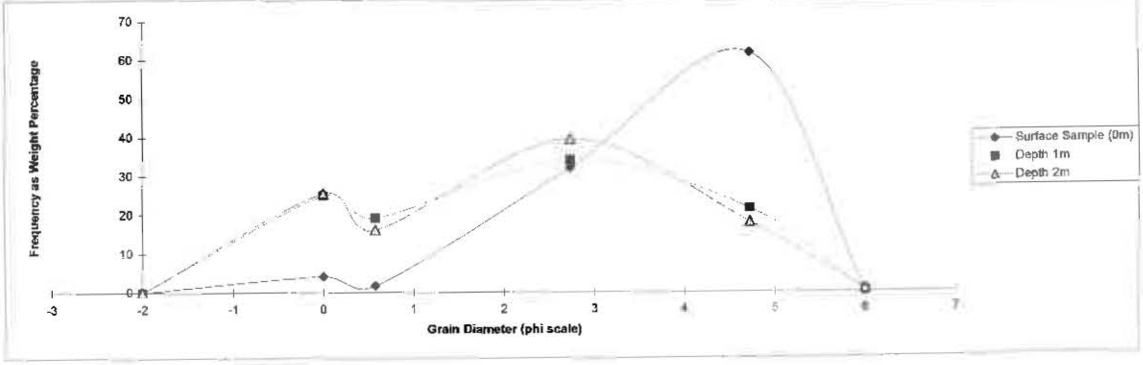
The size fractionation is noted to change throughout the depth profile of the sediment. The surface sediment largely consists of silt and some very fine sand, with significantly lesser proportions of medium to coarse grade sand (Buller & McManus, 1979). The surface sediment is poorly sorted indicating the mobile nature of the sea bed surface. These observations are supported by the fact that the grain size distribution of the surface sediment is leptokurtic (having greater kurtosis than the normal distribution) in nature, and is negatively skewed towards the coarser grades. This indicates that the surface sediment is a mixture of a predominant fine population with a very subordinate coarser population (Folk, 1966).

Negative skewness of sands is usually due to winnowing. Winnowing is characteristic of a beach environment. On a marine beach, sand is exposed to two forces of unequal strength acting in opposite directions. The incoming waves and the outgoing wash remove the finer grained particles. The frequency distribution curve of a winnowed sand lacks the 'tail' at the fine-grained end of the curve and the sand is negatively skewed (Friedman, 1961). The surface sediment of Site L has obviously been affected by winnowing. Site L lies about 50 m from a rock wall and there is the predominantly northerly surge of incoming waves over the site, which then hit the rock wall and, as a consequence, the direction of the outgoing wash is reversed, which would cause this typical winnowing effect on the surface sediment.

The frequency distributions of the sediment samples collected at depths of 1 m and 2 m were very similar. The distribution of these samples were weakly bimodal with the primary and secondary modes less sharply defined and relatively symmetrical. This indicates that the sediment largely consists of a mixture of fine to very fine grade sand, and very coarse to coarse grade sand, with lesser proportions of granules, medium sand and silt. The fact that the sediment is well sorted indicates the sediment below 1 m is essentially immobile and stable.

The high calcium concentrations and strong efforescence during acid digestion of the surface and depth samples, indicated that the sediment is primarily calcareous in nature. Generally, all metal concentrations tended to decrease with increasing depth. However, there were elevated levels of iron, manganese and aluminium in all three sediment samples, with the surface sediment having levels approximately twice that of the respective depth samples. Heavy metals are most commonly associated with fine organic-rich sediment fractions which occur on the sediment surface. In addition, living plant matter and algae, which also occur on sediment surfaces, will contain significant concentrations of heavy metals if contaminated. Hence, this is the reason for the metal concentrations being greater in the fine, surface sediment, with the subsequent decrease in heavy metal concentration as the depth into the integrated sediment column increases. The elevated levels of iron, aluminium and manganese in the sediments would probably have resulted from the degradation of metal components and artefacts on the shipwreck, and not from anthropogenic sources.

All sediment samples show sulphate values greater than the investigation level quoted for contaminated soils, indicating contamination of the upper sediment column. The sulphate may have originated from industrial sources—thermally labile, naturally occurring organic compounds, like some mercaptans and sulphides, and from anaerobic bacterial activity. The samples also showed slightly elevated levels of potassium. High concentrations of potassium indicate accumulation of organic matter. Increased organic content and the high concentration of sulphate in the sediment will provide conditions for vigorous bacterial




*Histogram of grain size distribution of Site L sediment.*

reduction so that the sediment layers will be commonly anaerobic and charged with hydrogen sulphide.

The results of the organic extract analysis of these sediments did not indicate the presence of excessive amounts of semi-volatile organic pollutants, including polyaromatic hydrocarbons.

The results of the inorganic analysis of the bulk sea-water samples collected on the surface and at the sediment surface and sea-water interface, were as expected, and showed little variation in major constituents with slightly elevated nutrient values, that is, increased concentrations of nitrogen (N) and phosphorus (P) (Table 5). The elevated N and P levels in the pore water of the sediment samples indicate a significant store of nutrients in the sediment and the interstitial water.

*Table 5. Nutrient values (mgl$^{-1}$) of the bulk sea water samples and pore water extracted from the sediment samples.*

| Sample | P_SR | Porg | Ptotal | N_NH3 | N_NO3 | Norg | Ntotal |
|---|---|---|---|---|---|---|---|
| sea-water surface | <0.01 | >0.01 | 0.02 | 0.07 | <0.02 | 0.03 | 0.12 |
| sea-water 3 m depth | <0.01 | >0.01 | 0.02 | 0.06 | 0.03 | 0.01 | 0.10 |
| pore water surface | 0.04 | 0.05 | 0.09 | 16.00 | 0.80 | 2.20 | 19.00 |
| pore water 1 m | 0.01 | 0.09 | 0.10 | 0.90 | 1.00 | 0.10 | 2.00 |
| pore water 2 m | 0.05 | 0.06 | 0.11 | 0.40 | 0.30 | 0.30 | 1.00 |

Atkins *et al.* (1980) report that nuisance algal growth could be expected when concentrations of inorganic P and N equalled or exceeded 0.01 mgL$^{-1}$ and 0.03 mgL$^{-1}$, respectively. Inorganic N levels may, at least, partly control or limit phytoplankton growth. However, the inorganic levels of N and P in the bulk sea-water do not exceed the quoted nuisance values. Alternatively, the P and N levels of all pore water samples exceed this limit.

The inorganic and organic P concentrations in the pore water and sea-water samples are about half of the total P concentrations. This implies that approximately half of the P in the pore waters is in inorganic forms, and some in organic forms or associated with and bound to particulate matter. Some of the organic N and P in the water column will be tied up in the phytoplankton, and the remainder probably originates from the stirring of the sediment which is unavailable for phytoplankton uptake.

The total N concentrations in the sea-water and pore waters appear at similar levels as the total inorganic N. This implies that the N is mainly in inorganic forms and is available for phytoplankton uptake. This increase in soluble, inorganic N forms will increase microscopic plant production which, in turn, can upset the base of the normal food chain and result in degrading masses of plant material and decreases in dissolved oxygen content, pH and redox potential of the water column. This will directly affect the degradation of the shipwreck and associated artefacts. On the other hand, nutrient accumulation may cause increased colour and turbidity, which reduces light transparency of the water and can suppress algal growth.

The pore water samples extracted from the surface sediment contained a higher concentration of N than the samples extracted from the sediments collected at depth. This is to be expected as nutrients are closely associated with organic particulate matter present on the sediment–water column interface, where most biological activity occurs.

The calcium content of the pore water extracted from the sediment collected at depth was more than twice that of the pore water in the surface sediment and the bulk sea-water. This could cause increased scale-forming tendencies on artefacts and vessel components buried in the sediment.

## Conclusions

Site L lies partially buried in the north-western end of Galle Harbour, in close proximity to large storm water drains. The open-water column of Site L is an aerobic, oxidising marine environment with a lower average salinity and dissolved oxygen content than the open ocean. Temperature, salinity and dissolved oxygen content can vary greatly in harbours compared to the open ocean, which undergoes only very minor fluctuations. The influx of fresh water from the drains and direct precipitation would reduce the overall salinity of the sea-water in this area. The lower salinity and dissolved oxygen levels also indicate that there is reduced exchange of sea-water in the harbour with the open ocean. The reduced average salinity and dissolved oxygen content and the higher temperature of the water column will effectively decrease biological activity and the degradative processes occurring on-site.

The exposed iron and lead on this site is actively corroding, and the condition of exposed metals on-site was as expected, as the water column is an aerobic, oxidising marine environment. However, if it is assumed that the shipwreck is the *Avonster* (1659), then the mean corrosion rate for cast iron exposed on this site is calculated at 0.035 mmy$^{-1}$. This is approximately one-third the standard corrosion rate for isolated iron in aerobic sea-water, which is 0.1 mmy$^{-1}$. The decrease in the overall corrosion rate on Site L would be due to the higher water temperature, the lower dissolved oxygen levels and salinity, and the fact that the vessel has been mostly buried for a considerable period of time.

In general, the aerobic wooden structural timbers on Site L are extremely well preserved. There is some evidence of marine borer attack but it is not extensive, indicating that this site is extensively buried for extended periods of time. Basically, the aerobic timbers possess a degraded outer surface layer, varying in depth depending on the position on-site, progressing to an area of partial degradation surrounding a relatively undegraded wood core. The good condition of the aerobic timbers may be attributed to the site being only recently exposed. As would be expected, the anaerobic timbers are in excellent condition because the wood is predominantly protected from extensive physical and biological deterioration.

The perimeter of the vessel is heavily scoured and the shoreward sides of the hull remains are more exposed and appear more degraded than the seaward-facing sides. The predominantly northerly direction of the swell and waves traversing the site causes scouring of the in-shore timbers and deposition of the sediment on the opposite, seaward face. Therefore, the apparent increase in degradation of the shoreward-facing timbers would be due to differences in the physico-chemical micro-environments between both sides of the vessel. In addition, outer planking covered in anaerobic concretion formed from the corrosion of iron sheathing nails used to secure the sacrificial planking was much less degraded than other timbers, regardless of the position on-site. The anaerobic concretion and the previous burial in the sand would have protected these timbers by decreasing the physical, chemical and biological deterioration of the wood. In summary, it is proposed that physical degradation and, to a lesser extent, biodeterioration, are the major mechanisms causing the *in situ* degradation of this wooden vessel; and, in conjunction with protection afforded by burial, it appears that the original measures taken to protect the vessel from the ravages of marine organisms have been effective in providing continued protection to the exposed hull remains of the shipwreck.

The sediment on Site L was essentially sterile with respect to artefact material, and this suggests that the site has been heavily salvaged in the past. The surface sediment largely consists of a poorly sorted mixture of silt and some fine sand, with significantly lesser proportions of medium to coarse-grain sand. The sediment has been affected by winnowing, and wave action has dominated the deposition, indicating the mobile nature of the surface sediment. The sediment below 1 m is well sorted, and largely consists of an almost equal mixture of very fine to fine-grade sand and coarse to very coarse-grade sand, with very little granules, medium sand and silt. Therefore, it is evident from these results that the surface sediment is dynamic, but the sediment is immobile and stable at depths greater than 1 m.

The sediment is calcareous in nature and does not contain excessive quantities of heavy metals or volatile organic pollutants including polyaromatic hydrocarbons. The elevated levels of iron, aluminium and manganese in the sediment would probably have resulted from the degradation of metal components and artefacts on-site and not from anthropogenic sources. These elements can be easily released into the water column on disturbance of the sediment and may affect secondary colonisation of concreted marine artefacts positioned on the sediment surface and, hence, the degradation rate of the artefact materials.

All sediment samples contained large quantities of sulphate, which would provide conditions for vigorous bacterial reduction. Subsequently, the rate of deterioration of buried artefact material will be affected. In general, the rate of metal corrosion will decrease and organic materials will be protected. However, with the high concentrations of iron in the sediment, buried organic materials will be impregnated with large quantities of iron sulphides, which can cause post-conservation problems after stabilisation. The major corrosion products present in organic materials need to be characterised prior to the commencement of the treatment regime so that these problems can be minimised.

The sediment is also severely polluted with high nutrient levels. Sediment disturbance by violent swells and wave action during the monsoon seasons would release the high concentrations of phosphorus and nitrogen, increasing the nutrient level in the surrounding water column, which already has slightly elevated levels of these elements. Increases in these nutrient levels released from the disturbed sediment will be followed by increases in the abundance of algae and epiphytes. Degrading plant material will also decrease dissolved oxygen contents, pH and redox potentials of the immediate water column and the surface sediment, which will, in turn, alter degradation mechanisms and affect the deterioration of the vessel and its artefacts.

In conclusion, it is obvious from this survey that Site L is a chemically and physically dynamic site. There are many synergistic and opposing chemical and microbiological reactions occurring on the site, which makes predicting the overall effect of this site on the rate of degradation of artefact material very difficult. However, in general, the buried hull remains have been protected by the sediment and are in sound condition after approximately 300 years of immersion in this marine environment. Alternatively, the exposed sections of the wreck are slowly being destroyed. It is mainly physical mechanisms and, to a lesser extent, biodeterioration that is causing the *in situ* degradation of this wooden vessel and its associated artefacts.

**Appendix 2 1997 Conservation management report**

Conservation Laboratory

After four seasons of archaeological investigation, a broad range of artefact materials have been observed

*Conservation Laboratory under construction*

on and in the sea bed of Galle Harbour. The number of artefacts recovered has been limited and controlled, sufficient to provide enough objects to assess the archaeological potential, provide artefacts for site identification, initiate research and enable a variety of materials to become available for conservation practice. The type of materials and size of objects recovered have been limited as dedicated facilities for storage and treatment of maritime archaeological artefacts were not available. Artefacts requiring special treatment had to be conserved at the Central Conservation Laboratory at Anaradapura which is focused more on land archaeological finds.

One of the recognised requirements from the outset of the programme has been the need to establish a conservation laboratory dedicated to preserving maritime archaeological artefacts. Plans were prepared, based on an existing building and information pertaining to the infrastructure provided. Motivated by the extensive archaeological potential of Galle Harbour and the potential threat to archaeological sites by harbour development, the work has begun on the conversion and fitting out of the building.

Based on the original concepts outlined in Carpenter & Richards (1993), an accurate and comprehensive series of building plans have been prepared for the laboratory (State Engineering Corporation of Sri Lanka), which is now under construction. Progress with the construction has been slow and, as a result, the facility has not been operational during the recent expedition. A request for the construction of a concrete storage tank for artefacts was met with a prompt response; however, a delay in fitting a drainage valve prevented its use until almost the end of the 1997 programme. Three stone anchors are presently immersed in fresh water in this tank. A steel tank for the proposed conservation treatment of an iron cannon was not available due to problems with the steel supplies.

Prior to the Australian contingent's arrival, it had been planned that a single section of the laboratory (restoration room) should be completed in order to provide a secure area for conservation work, storage and artefact treatment. This room was not finished in time for the 1997 season's work and it has meant that most aspects of conservation continued to be performed at Nooit Gedacht, the headquarters of the programme.

The frequent visits by conservation personnel to the laboratory have allowed consultation with the project manager to take place; this has drawn attention to problems and resulted in minor additions and construction changes which will improve the facility. Such visits should continue throughout all phases of construction and fitting out. Every attempt should be made to complete the laboratory prior to the next season of the Galle Harbour Project.

It is important that the person appointed as head of the Conservation Laboratory has conservation training; at the very minimum, they must have a chemistry background. A minimum of two persons are needed to run the laboratory.

Conservation of artefacts

The largest artefacts recovered are an assortment of stone anchor's and the biggest of these is the Arab-Indian type GHP 30, which has arms of wood associated with it.

An on-site conservator assisted with actual artefact recovery and care during transportation (diving conservator requirement). On arrival at the conservation work area (Nooit Gedacht), the artefacts were sorted into material types and given site identification codes and registration numbers. Initial storage depended on material type, with copper alloys and coal being allowed to dry; the other materials were stored wet. The wood from the anchor GHP 30 could not be stored immersed, so it was watered down, then wrapped and sealed in polythene (100 % humidity).

Other than the two pieces of wood from anchor GHP 30, only two small wood samples were acquired from what may be a spar from the wreck at Site L (believed to be the *Avondster*). As several wood samples were collected during previous investigations of this site, further sampling was not warranted. These recent samples, however, may be appropriate for comparative analysis with the wood from the anchor GHP 30. Both appear to retain similar states of preservation.

*Iron (concretions)*

Long term soaking of the iron objects in sodium hydroxide (2%) is recommended to remove salts. Since these artefacts have thin cross-sections attempts to remove concretion is likely to destroy any remains. As concretion retains the original shape of an object, the example x-radiographed will provide some information and guide the production of a drawing. Samples taken for analysis or identification at the Western Australian Museum

*Wood samples*

Wood for species analysis, degradation assessment and Carbon 14 dating
Samples from GHP 44 anchor arm (small)
GHP 44 ( a, b)
Samples from GHP 45 anchor arm (large)
GHP 45 ( a, b, c, d, e, f )
Sample from possible spar at Site L
GHL ( a, b )

*Stone samples*

Stone samples for petrogyphic analysis and source determination
GHP 30 Large Arab-Indian Anchor
Reg Nos GHP 30 ( a, b, c, d, e )
GHP 31 Broken Anchor 1997
Reg Nos GHP 31 ( a, b, c, d )
GHP 32 Four Hole Anchor
Reg Nos GHP 32 ( a, b, c )
GHP 76 One Hole Anchor
Reg Nos GHP 76 ( a, b, c)

Note, samples of stone from anchors GHP 30,31 and 32 and samples of ballast stone and local stone from Site G have been examined in Sri Lanka.

*Treatment location for artefacts*

During previous seasons, artefacts have been transported to the Central Conservation Laboratory at Anaradapura for continuing conservation and storage. Since, at the time of writing, the Galle Conservation Laboratory is not complete, this process may have to continue. This issue needs to be addressed, and, particularly, the ultimate destination for the artefacts as a collection for study and exhibition. If the Galle Maritime Museum is to be used for this purpose, an environmental assessment will need to be carried out.

Maritime archaeological conservation in Galle

The benefits of involving the Western Australian Museum's Department of Materials Conservation in the programme in Sri Lanka have been a twofold: the transfer of knowledge through a conservation training programme (held in conjunction with a maritime archaeology training programme); and the provision of conservation support for archaeological investigations in Galle Harbour. Three conservation staff from the Western Australian Museum have contributed to the programme, with the preferred requirement being for two individuals to participate in the expeditions at any one time.

A conservation training programme

The conservation training programme was initially presented in the form of a series of illustrated lectures, supported by tutorials and practical conservation sessions involving artefact materials recovered during the course of investigations of underwater sites in the Bay of Galle. Specifically related conservation guidelines and treatment advice was prepared before departure for Sri Lanka so that conservation reference information would be accessible during and after the expedition.

Lectures presented:

1. The Department of Materials Conservation Western Australian Museum—conservation facilities and work procedures.
2. Establishing a conservation facility in Galle.
3. Common ground: Sri Lanka–Western Australia Fremantle's first harbour, the Long Jetty site in Bathers Bay, compared with Galle Harbour.
4. The marine environment.
5. An introduction to on-site conservation.
6. On-site conservation measurements (tutorial).
7. Ceramics, glass and stone—deterioration (tutorial).
8. Treatment of metals.
9. Specific treatment methods for metallic objects.
10. Deterioration of organic materials.
11. Polyethylene Glycol (PEG) treatment of waterlogged wood.
12. Alternative treatments of waterlogged wood (tutorial).
13. Treatment of waterlogged leather (tutorial).
14. Conservation of waterlogged bone and ivory.
15. Treatment of waterlogged rope.
16. Treatment of waterlogged textiles.
17. Degradation and conservation of wood–metal composite artefacts.

Workshops and practical sessions:

1. Use of on-site data-recording equipment.
2. Plotting conductivity and chloride data during desalination of artefacts.
3. Photographic documentation of artefacts.
4. Deconcretion and conservation of lead sounding weights (*Hercules* site).
5. Deconcretion and alkaline dithionite treatment of silver coins (Great Basses Reef site).
6. Storage and packing artefacts.
7. Artefact registration.

Video presentations:

1. Acquiring pH and Eh measurements underwater.
2. Conservation considerations when dredging (a method of exposing a wreck for recording and artefact recovery).
3. Artefacts, conservation procedures.
4. Great Basses Reef wreck site.
5. General underwater video of conservation work procedures documented when students could not participate.

The environmental conditions of underwater sites

One important aspect of on-site conservation which was explained and demonstrated (using video of the underwater procedure) to Sri Lankan personnel was the acquisition of pre-disturbance information (mainly environmental data), including pH and Eh (corrosion potential) measurements. This important role for conservators requires that the personnel involved are trained scuba divers. A diver training programme which has been initiated focused on qualifying potential maritime archaeologists; in the future this should be extended to conservators. The type and extent of information usually required is listed here:

Data acquisition list:

Site (name or designated identification code)

Date(s) of inspection

Weather and sea conditions

Location

Description

i) Wreck site

ii) Fauna and flora assemblages

iii) Fresh-water influence

Wreck (general observations)

Extent of site exposure

Evidence of seasonal exposure variation

Evidence of interference (looting, salvage, pollutants, etc.)

Exposed structure and artefacts (type and material make-up described)

Electrochemical survey, pH and Eh (corrosion potential measurements)

Concretion and metal thicknesses (determination of length of immersion time and, therefore,

structural integrity)
Samples (artefact or structural materials—mainly wood identification)
Samples (for environmental assessment—mainly sediments)
Samples (marine fauna and flora—subject to availability of marine biologist)
Seawater
Oxygen content, salinity and presence of nutrients

Interpretation of this data enables the conservator to provide the archaeologist with information pertaining to the environment of the underwater site and relate this to the specific condition (or survival potential) of materials which comprise the site, i.e. the condition of artefacts and structural components. In the broader sense, this will assist in prioritising investigation and excavation of sites with respect to the likely rate of deterioration, disintegration and ultimate loss. Quantifiable influential environmental factors, such as the oxygen content of sea-water and the presence of nutrients which feed deleterious organisms can be recorded. All this information will form the basis for developing a sites management programme for the underwater heritage in Galle Harbour.

Future Training

The benefit of having previous conservation participants was evident, as direct and constant supervision was not necessary. Experienced additions to personnel were also of much benefit. The lectures and tutorials given in the early stages of the Galle Harbour Project (1992–93) were not repeated, however, illustrated refresher talks were given, and specific discussion was held with respect to artefact treatment procedures.

At the close of the expedition all Sri Lankan conservation personnel were presented with a certificate of participation which acknowledged their individual contribution and achievements.

**Appendix 3. Preliminary geological-petrological analysis samples recovered from Galle Harbour**
Ananda Gunatailaka

*Sample 1—Ballast*

The examined sample is a spherical mass about 100 mm in diameter. Hand examination of a freshly broken surface of the specimen indicates that it is a coarse-grained mafic to ultamafic igneous rock, with distinct phenocrysts or xenoliths of olivine and pyroxene crystals (mostly). The olivine nodules are being altered to a yellowish-green mass of probably serpentine at the surface. The largest nodule is about 10 mm in length, while the pyroxene crystals were up to 4 mm in length. The sample is of high specific gravity (>3.5).

A microscopic thin-section examination (three thin-sections were prepared) of the above rock shows mostly euhedral, well-zoned or unzoned pyroxene crystals and olivine nodules (forsterite composition), which are either fresh or in various alteration stages to serpentine. Pyroxene and olivine are the dominant minerals, making up about 75–80% of the rock with pyroxene > olivine. A few crystals of plagioclase felspar (labradorlte-bytownite composition) are evident, but make up less than 2% of the rock. These three minerals show breakage or fracturing, indicating that the cooling magma was subjected to an explosive event. The most distinctive aspect of the rock is the high proportion of iron-oxides (magnetite?), making up about 8–10% in volume. The ground mass was indeterminate, but may have substantial amounts of pryoxene. The three major silicate minerals form an interlocking texture under the microscope.

The above composition and texture, with the very small amount of felspar, appear to suggest a rock of peridotitic composition (ultramafic). On the other hand, the fractured nature of the crystals—suggesting an explosive episode during cooling—probably indicates an original mela-alkaline magma which filled up and crystallised in a volcanic vent or crater at depth—which is akin to a volcanic plug. The above composition indicates why the rock would have made ideal ballast material (high iron content in the minerals).

It is not possible to say whether the original rock was fashioned into spheres at a quarry for the specific purpose of using as ballast or whether the spherical masses represent some extreme example of natural spheriodal weathering. It is possible that the rock spheres were excess cannon-ball from a previous historical period, which were later found to be ideal ballast material. In any case, spheres of identical diameter would make for easy packing, stacking and storage in a ship (cf. the ideal cubic or hexagonal close packing of spheres in nature).

The rock could have come from anywhere else, but were definitely not from Sri Lanka. The author is familiar with similar rocks of Carboniferous-Permian age in Glasgow, Scotland. Similar rocks are known from Italy, Norway, Saudi Arabia, Aden and, perhaps, from the Pyrenees region. They are not known from the Low Countries of Europe (Holland, Belgium or Brittany coast). A detailed chemical analysis of the rock could probably indicate its provenance by matching it to an existing petrochemical database of similar rocks.

*Sample 2—Long stone anchor*

The anchor is about 1.5 m in length and was fashioned out of a sedimentary rock called a conglomerate. Conglomerates are coarse-grained rocks made up of one or more clast types. Examination of this anchor, which was displayed outside the Galle Maritime Museum within the Galle Fort, indicated that the rock is made up of several clast types of various sizes and shapes. The largest clast size is as much as 40 mm in length and the smallest size grades down into a sandy matrix in which the larger clasts are embedded. The clasts are angular to well rounded. These features indicate a very poorly sorted rock (polymodal grain sizes), which in geological terms could be described as a polymict conglomerate. The rock is cemented almost exclusively of calcite, which fills up the pore spaces between the grains.

Clast composition. The clasts are predominantly made up of chert and quartz (both mono and polycrystalline grains) of pebble to sand size. In addition to these are clasts of fine sandstone, marl, limestone, shale and dark brown fragments of iron-stained materials. Under the microscope, these brownish grains appear to be ophiolitic in composition (now altering to serpentine). In addition to this, there are occasional felspar grains, shale and trachyte clasts. The matrix is mainly chert and quartz. The rock is cemented by calcium carbonate (calcite) which is the main pore-filler. At least three generations of carbonate cement can be seen. The rock can be described as a polymodal or poorly sorted polymict conglomerate.

These rocks are quite common in alluvial fan or fan delta complexes flanking rising mountain fronts or fault scarps (half-grabens). Along both flanks of the mountains of Oman, the author has seen very similar conglomerate formations several hundreds metres in thickness.

Provenance. The author is certain that the above anchor originated in Oman. The chert-ophiolite-fine sandstone (probably turbiditic) clast association in conglomerates is typical of the alluvial fan formations of the Oman Mountain front. In addition, marl, shale and limestone are very common rocks in Oman's mountains. Further, these conglomerate formations are ubiquitous along the mountain front along the Omani coast-line, which has been well known since medieval times for its shipbuilding. Even today, there are several boatyards that are building dhows—the most famous of them being the village of Sur on the coast. These conglomerate formations were, and are, within walking distance of the shipyards. Further, it is known that although Omanis used grappling anchors in their ships, they also used stone anchors for mooring their vessels. These observations could be no more than coincidental but the author's many years of geological experience in Oman, and his familiarity with its geology, are the main reasons for his opinion that the anchor had a Omani provenance.

It is certain that this rock type and its composition is not found in Sri Lanka. In fact, the author cannot think of any place in the region excepting Oman, where such a conglomerate has been described.

*Sample 3—Flat sandstone anchor*

This is a well-laminated sandstone anchor made up of essentially coarse-grained quartz and comminuted shell material. The grains are cemented by $CaCO_3$ (spar calcite). The rock from which this anchor was made is very likely a beach sand that is commonly seen in many coastal areas of the world. The anchor could have come from anywhere.

*Sample 4—Square anchor*

This is very much like a beach rock and is made up of mostly shelly material and quartz grains. No bedding or lamination was developed in the rock. It is heavily bored by various marine boring animals, giving the rock a honeycomb-like effect. Such rocks formations can be found today in many coastal areas of the world. The author has seen such rocks all along the Arabian coastal zone, from Abu Dhabi to Kuwait. It is a heavily bored, shelly, sandstone beach rock.

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**Appendix 5 Acknowledgements**

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## Appendix 6. 1997 Artefact catalogue

| | | | | |
|---|---|---|---|---|
| 1997GHG1 | 1 | 2 ships' nails, larger: 160mm | 25-10-1997 | G |
| 1997GHG2 | 2 | Lead sheet, 60mm x 120mm | 25-10-1997 | G |
| 1997GHG3 | 3 | Iron bolt, 270mm, cross section 17x17mm | 25-10-1997 | G |
| 1997GHG4 | 4 | Copper alloy sheathing fragment, with nail perforation | 25-10-1997 | G |
| 1997GHG5 | 5 | Copper alloy sheathing nail, 31mm. Dia.10mm | 25-10-1997 | G |
| 1997GHG6 | 6 | 3 copper alloy ships' nail fragments | 25-10-1997 | G |
| 1997GHG7 | 7 | Stonenware, bodysherd , salt glazed, two tone body. European.Found at the base of the cliff, mid site | 25-10-1997 | G |
| 1997GHG8 | 8 | Wood fragment, with nail hole | 25-10-1997 | G |
| 1997GHG9 | 9 | Iron concretion , 390 mm (length), 70mm(width) | 25-10-1997 | G |
| 1997GHG10 | 10 | 3 pieces of copper alloy sheathing | 28-10-1997 | G |
| 1997GHG11 | 11 | Brass bolt , length 205mm | 28-10-1997 | G |
| 1997GHG12 | 12 | 2 copper nail fragments | 28-10-1997 | G |
| 1997GHG13 | 13 | 3 copper alloy sheathing tacks | 28-10-1997 | G |
| 1997GHG14 | 14 | 2 pieces of coal | 28-10-1997 | G |
| 1997GHG15 | 15 | Earthenware, bodysherd,Aproximatcly 3.5mm | 28-10-1997 | G |
| 1997GHG16 | 16 | 3 earthenware, iron glazed , bodysherd | 28-10-1997 | G |
| 1997GHG17 | 17 | Piece of clear white glass from a bottle | 28-10-1997 | G |
| 1997GHG18 | 18 | Large piece of coal, | | |
| 1997GHG19 | 19 | 4 copper ship nails (Two nail samples -Australia) | 29-10-1997 | G |
| 1997GHG20 | 20 | Copper, sheathing fragments with nail holes | 29-10-1997 | G |
| 1997GHP21 | 21 | Clear glass bottle, body and base | 29-10-1997 | P |
| 1997GHG22 | 22 | wood fragment | 29-10-1997 | G |
| 1997GHG23 | 23 | ballast stone fragment | 29-10-1997 | G |
| 1997GHP24 | 24 | 5 samples of the large stone anchor (anchor no: 1) | 29-10-1997 | P |
| 1997GHP25 | 25 | 1 sample of anchor no. 2 (incomplete 1993) | 29-10-1997 | P |
| 1997GHP26 | 26 | 1 sample of anchor no. 3 (new anchor 1997) | 29-10-1997 | P |
| 1997GHG27 | 27 | Copper alloy bolt, 340mm length, dia15mm | 31-10-1997 | G |
| 1997GHG28 | 28 | Jar, base , with iron glaze on interior, buff, Far Eastern | 31-10-1997 | G |
| 1997GHL29 | 29 | Jar, beardman, bodysherd | 31-10-1997 | L |
| 1997GHP30 | 30 | Stone Anchor (complete),made from conglomarate of small stones and pebbles,bound in yellow | 4-11-1997 | P |
| 1997GHP31 | 31 | Stone anchor (broken),made from sandstones | 4-11-1997 | P |
| 1997GHP32 | 32 | Stone Anchor (flat form),"Mediterranean type" made of sandstone, dimension 1m long | 4-11-1997 | P |
| 1997GHP33 | 33 | Stone Anchor (recent- modern use) ,with chain concretion, possible quarry stone (local) | 4-11-1997 | P |
| 1997GHG34 | 34 | Sheathing nail | 12-11-1997 | G |
| 1997GHP35 | 35 | 2 earthenware, bodysherds | 11-11-1997 | P |
| 1997GHG36 | 36 | Earhenware, lid sherd | 12-11-1997 | G |
| 1997GHP37 | 37 | Earthenware , lid sherd, 300mm long, 110mm wide | 12-11-1997 | P |
| 1997GHP38 | 38 | Slate, with tally | 13-11-1997 | P |
| 1997GHP39 | 39 | Earthenware, lid fragment | 13-11-1997 | P |
| 1997GHG40 | 40 | Wood fragment | 14-11-1997 | G |
| 1997GHG41 | 41 | Stoneware, bodysherd | 14-11-1997 | G |
| 1997GHG42 | 42 | Copper alloy, sheathing fragment | 14-11-1997 | G |
| 1997GHG43 | 43 | 7 ballast stones (they are for geological sampling ), samples given to Dr. Ananda Gunathilake. | 14-11-1997 | G |
| 1997GHP44 | 44 | Piece of timber (medium) 98 cm x 16 cm | 14-11-1997 | P |
| 1997GHP45 | 45 | Large piece of timber 134 cm x26 cm | 17-11-1997 | P |
| 1997GHP46 | 46 | Earthenware, pot rimsherd,large | 14-11-1997 | P |
| 1997GHP47 | 47 | Earthenware, pot ,rimsherds, with decorations | 14-11-1997 | P |
| 1997GHP48 | 48 | Earthenware, pot, bodysherds17 pieces | 14-11-1997 | P |
| 1997GHP49 | 49 | 2 Earhenware, bodysherds, grey | 14-11-1997 | P |
| 1997GHP50 | 50 | 2 Tile sherds, big- 190 (L)small 100(L) | 14-11-1997 | P |
| 1997GHP51 | 51 | Earthenware, pot bodysherd, (incised) decorations on exterior | 14-11-1997 | P |
| 1997GHP52 | 52 | Earthenware, pot, bodysherd, black | 14-11-1997 | P |
| 1997GHP53 | 53 | Plate, rimsherd and basesherd, willow pattern | 14-11-1997 | P |
| 1997GHP54 | 54 | 4 pieces, (1) jar, bodysherd, iron glazed ,far eastern(2) Soup plate, European(3) Dish, rim, European | 14-11-1997 | T |
| 1997GHP55 | 55 | Bone fragment | 17-11-1997 | P |
| 1997GHP56 | 56 | Earthenware, 8 jar rimsherds, decorative, 3 pot rimsherds | 17-11-1997 | P |
| 1997GHL57 | 57 | 2 bowl basesherds, with blue and white painted decorations , far eastern | 17-11-1997 | L |
| 1997GHP58 | 58 | Stoneware, jar,basesherd, iron glazed on exteriorFar eastern | 17-11-1997 | P |
| 1997GHP59 | 59 | 2 earthenware, bodysherds, (1) paddle impressed chequer decoration, (2) linear incised | 17-11-1997 | P |
| 1997GHP60 | 60 | 10 earthenware, pot, bodysherds | 17-11-1997 | P |
| 1997GHP61 | 61 | Piece of coal, 150mm (L) | 17-11-1997 | P |
| 1997GHP62 | 62 | Bottle,base, with dimple, clear green glass | 17-11-1997 | P |
| 1997GHP63 | 63 | 5 pieces of iron concretion (1) 100mm (2) 115mm (3)110mm (4) 115mm (5) 180 mm | 17-11-1997 | P |
| 1997GHP64 | 64 | Piece of coal110mm (L) | 18-11-1997 | P |
| 1997GHP65 | 65 | Earthenware, jar, bodysherd | 18-11-1997 | P |
| 1997GHP66 | 66 | Earthenware, bodysherds, 3 pot sherds, 1 jar sherd | 18-11-1997 | P |
| 1997GHP67 | 67 | 5 pieces of earthenware, pot, rim sherds | 18-11-1997 | P |
| 1997GHP68 | 68 | Earthenware, jar, rim sherd , black and brown, decorative | 18-11-1997 | P |
| 1997GHP69 | 69 | Earthenware, jar bodysherd, inscribed decorations | 18-11-1997 | P |
| 1997GHP70 | 70 | Plate, rim to base sherd, white,European frittware with glaze," IRON STONE (lion mark) J & " | 18-11-1997 | P |
| 1997GHP71 | 71 | Iron concretion, 190mm (L) 70mm (w) | 18-11-1997 | P |
| 1997GHP72 | 72 | Iron slag | 18-11-1997 | P |
| 1997GHT73 | 73 | Ceramic plate, white, symbol on rim of upper surface,SPNO, Makers mark and stamped mark | 20-11-1997 | T |
| 1997GHL74 | 74 | Deck beam ? | 21-11-1997 | L |
| 1997GHT75 | 75 | Paving stone ?18,9cm (L), 14,3cm (W) | 24-11-1997 | T |
| 1997GHT76 | 76 | Stone anchor, square hole in center (could be local stone) | 24-11-1997 | T |
| 1997GHA77 | 77 | 3 clay, pipe, bowls | 25-11-1997 | A |
| 1997GHA78 | 78 | 7 pieces of coal | 25-11-1997 | A |
| 1997GHA79 | 79 | Bear bottle, complete,small, brown | 25-11-1997 | A |
| 1997GHA80 | 80 | Iron concretion | 25-11-1997 | A |
| 1997GHA81 | 81 | Earthenware, pot, neck/body ? | 25-11-1991 | A |
| 1997GHA82 | 82 | Bottle, base fragment,light green, indented | 25-11-1997 | A |
| 1997GHA83 | 83 | Bottle, neck fragment dark green | 25-11-1997 | A |
| 1997GHA84 | 84 | Bottle, neck fragment, light green | 25-11-1997 | A |
| 1997GHA85 | 85 | Bottle, base fragment with dimple,dark green,clear wm Milne & co, Glascow | 25-11-1997 | A |
| 1997GHA86 | 86 | Bottle, clear, flat base, small pieces of coal incide, colourless | 25-11-1997 | A |
| 1997GHA87 | 87 | Earthenware, jar, rim | 25-11-1997 | A |
| 1997GHA88 | 88 | Ceramic, | 25-11-1997 | A |
| 1997GHA89 | 89 | Frittware, lid ?, European | 25-11-1997 | A |
| 1997GHA90 | 90 | Bowl ,basesherd ,blue on white decoration, far eastern | 25-11-1997 | A |
| 1997GHA91 | 91 | Earthenware, jar. body sherd, red slipped inside | 25-11-1997 | A |
| 1997GHA92 | 92 | Bobbin shaped object ? possibly weight? | 25-11-1997 | A |
| 1997GHA93 | 93 | Murcurry jar,base | 25-11-1997 | A |
| 1997GHA94 | 94 | Earthenware, jar, bodysherd | 25-11-1997 | A |
| 1997GHA95 | 95 | Stoneware,jar. fragment of a handle, dark brown iron glaze on interior stopping above base,far eastern | 25-11-1997 | A |
| 1997GHA96 | 96 | Stoneware,bowl rim to basesherd, blue on white decoration, peony flower and two chincese characters on exterior, | 25-11-1997 | A |
| 1997GHA97 | 97 | Glass fragment, from port hole | 25-11-1997 | A |
| 1997GHL98 | 98 | Iron concreted, ring | 26-11-1997 | L |

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