The Australian Historic Shipwreck Preservation Project:

In-situ preservation and long-term monitoring of the *Clarence* (1850) and *James Matthews* (1841)shipwreck sites

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Abstract

Increasingly archaeologists are opting for on-site examination, reinterment and in-situ preservation of underwater cultural heritage sites as the first option in the management of sites at risk as opposed to the more traditional excavation, recovery, conservation and display/storage methods. This decision will inevitably be based on significance assessment, degree of perceived risk and resourcing issues. However, long-term monitoring must become an integral part of these management programmes in order to quantitatively evaluate the effectiveness of the in-situ preservation techniques employed. Absence of monitoring is equivalent to abrogation of responsible management and in some cases can be considered tantamount to cultural vandalism. In 2012 the Australian Historic Shipwreck Preservation Project (AHSPP) commenced, having secured funding through a substantial Australian Research Council Linkage Grant with 10 Australian Partner Organisations and three universities. One of the major aims of the project is to develop a protocol for the excavation, detailed recording and reburial of significant shipwrecks under threat, fostering a strategic national approach for the management of underwater cultural heritage sites at risk. Two historically significant shipwreck sites were chosen for this longitudinal comparative study – the Clarence (1850) located in Port Phillip Bay, Victoria and the James Matthews (1841) which lies in Cockburn Sound, Western Australia. Both sites have been preserved in situ using two very different but innovative remediation strategies. More importantly a long-term monitoring programme has been implemented which will characterise changes in the reburial environment and the effect on the reinterred materials. In this way, the efficacy of both in-situ preservation techniques will be systematically tested, providing a comparative analysis of practical protocols for the long-term protection and management of underwater archaeological resources.

Key words: *In-situ* preservation, Underwater cultural heritage, Shipwrecks, monitoring, Conservation management

Introduction

The AHSPP is a national collaborative project funded by an ARC Linkage Grant which commenced in February 2012. With ten state, territory and federal Partner Organisations and three collaborating universities, this is the largest multi-government, multi-institutional maritime archaeological project ever initiated in Australia. The idea of a national collaborative research project arose from the 2008 review of the Australian Commonwealth Historic Shipwrecks Program (HSP). The report suggested that the HSP had not developed a maritime specific conservation management planning process for underwater cultural heritage (UCH) sites including nationally standardised processes and procedures, capacity for the excavation of UCH sites that are considered under threat and general guidelines for site management and *in-situ* preservation of UCH material. The ASHPP aims to address some of these issues by investigating and preserving *in situ*, in accordance with the UNESCO *Convention on the Protection of the Underwater Cultural Heritage*, the *Clarence* (1850) shipwreck located in Port Phillip Bay, Victoria and the *James Matthews* (1841) which lies in Cockburn Sound, Western Australia. The *Clarence* was considered an ideal site for this project for a number of reasons. This early colonial Australian built vessel was test excavated and surveyed in the 1980s (Harvey, 1989), providing a baseline for ongoing longitudinal comparative research. The site is relatively small (16.5m length; 6.2m width) and easily accessible as it lies in 5m of water at a location close to the major population centre of Melbourne. The site is subject to continuing anchor damage by illegal recreational anglers as well as the natural impact of the strong currents experienced in Port Phillip Bay and is considered under serious threat. The ex-slaver turned colonial trading vessel, *James Matthews* was chosen as the second site. It is also relatively small (24m length; 6m width) and located 12km south of Fremantle, lying approximately 100m off shore in 2-3m of water. More importantly, it has been the subject of a long-term detailed *in situ* conservation management research programme with more than 10 years of accumulated data on the efficacy of three different experimental reburial strategies trialled on-site (Richards et al., 2009).The synergistic impact of industrial activity and natural near-shore sedimentary processes has resulted in continued exposure and rapid deterioration of the site. The implementation of appropriate long-term *in-situ* preservation strategies for both sites, supported by an extensive monitoring programme to assess the viability of the different methodologies, was of paramount importance. However, in order for any *in-situ* preservation strategy to be successful the following points must be addressed in the overall management plan:

1. Ascertain the extent of the site.
2. Assess the most significant physical, chemical and biological deterioration processes occurring on the site.
3. Assess the pre-disturbed local burial environment and the major factors affecting the long-term stability of the site.
4. Identify the major material types present on the site and their extents of deterioration.
5. Implement an appropriate *in-situ* preservation strategy or combinations thereof, to mitigate continued deterioration and stabilize the site long-term.
6. Implement a long-term monitoring programme to evaluate the efficacy of the implemented *in-situ* preservation strategy.
7. Provide alternative plans and procedures if the implemented *in-situ* preservation strategies are unsuccessful.
8. Conservation, storage and curation of any recovered artefacts.

Each of these points is integral to a process-based approach when assessing underwater cultural heritage sites and establishing successful long-term conservation management plans (Richards, 2011). All eight points were addressed through application of previous research results and during the development of comprehensive research designs that included extensive methodology components and monitoring programmes for each site prior to the implementation of any reburial strategies.

Clarence - Excavation, Conservation and *In-situ* Preservation

The first fieldwork period on the *Clarence* occurred from 16 April to 15 May 2012. All activities were conducted from a 18m x 12m jack-up barge, set 3.5m above sea level, located directly adjacent to the site. The deposition of 1700 UV stabilised polypropylene woven sand bags onto the site was

Fig. 1 Biological growth on the Clarence site in November 2013. (J. Carpenter)

executed from support vessels. Adverse weather limited the excavation to only 9m of the starboard side, which was fully recorded. Only 35 artefact assemblages were recovered and kept wet at all times with seawater as opposed to fresh water to avoid osmotic shock when reburied. After full documentation the artefacts were prepared for reburial by wrapping them in polyester geotextile (Bidim A14), followed by a high density polyethylene shade cloth protective wrapping (Coolaroo Exterior Fabrics - Extra Heavy (84-90% UV Block) secured by cable ties. The artefacts were then placed in wet storage until the reburial phase of the project commenced.

Previous research has established the 50cm datum as the minimum depth of burial for the protection of recovered artefacts (Nyström-Godfrey et al., 2011). It was decided that the few, smaller metal, glass and ceramic artefacts could be reinterred on the wreck site as it would be possible to obtain greater than 50cm of sediment coverage. However, because they were different material types they had to be separated by at least 50cm in order to minimise the chances of unwanted chemical interactions.

Owing to the larger size of the packed organic artefacts, it was not possible to rebury them on-site, therefore they were reburied in an off-site storage depot in order to obtain the minimum depth of burial. A proprietary 2000L high density polyethylene water tank was purchased, the ends cut off and the tank sawn in half. This cylinder (1.0m height; 1.2m diameter) was then dredged into the seabed about 10m south of the stern. The sand was dredged from within the confines of the cylinder and the least degraded organic artefacts placed at the bottom of the depot, covered with 10cm of surrounding sand then the more fragile organics were placed on top of this layer. The depot was then backfilled with surrounding sediment, covered with shade cloth and anchored with polypropylene sand bags.

Towards the end of the fieldwork period, the excavated area including the reinterred artefacts was backfilled with dredged sediment from the site, however due to the fine nature of the clay deposit some was lost from the sediment traps and therefore the forward section of the excavation trench was backfilled with proprietary sand emptied from the sand bags on the site. Unfortunately, the weather deteriorated so it was not possible to adequately rebury the entire excavation trench and the off-site reburial depot to the minimum 50cm datum. These areas were stabilised with a layer of shade cloth and additional sand bags as an interim remediation measure.

Three weeks later saw the reburial of the excavation area and the depot with further proprietary sand so that an average reburial depth of 1m was achieved. This was considerably deeper than the pre-disturbance sediment profile. The backfilled areas were then stabilised with a layer of shade cloth, anchored with more sand bags until the final phase of the remediation strategy could be completed later in the year.

In November 2012 the final phase of the *in situ* preservation strategy commenced. This entailed filling and depositing a further 1800 sand bags on the site, removing the sand bags and shade cloth deployed in June, repositioning and adding more sand bags to adequately support some of the higher profile structural features on the port and starboard side of the wreck, covering the site with a shade cloth mat and finally protecting the site with polyvinyl chloride (PVC) tarpaulins.

A pre-prepared 250m^2 shade cloth mat (3 x 25m long x 3.66m wide sections joined together by cable ties) was deployed flush over the entire site conforming to the undulations of the wreck profile. The shade cloth was folded in a concertina fashion, which allowed the entire mat to be fanned out, starting down current, without recourse to deploying it in separate sections. The mat was then anchored with approximately 250 sand bags. The shade cloth mat will encourage the formation of an anaerobic environment in a relatively short period of time. However, because the shade cloth could be severely damaged by anchors it was covered with three 7m x 14m x 2mm PVC tarpaulins for further protection.

The tarpaulins could not have been placed directly onto the site without the underlying shade cloth mat because a) the PVC was just negatively buoyant and relatively inelastic so the tarpaulins could not conform closely to the site profile leaving large water spaces around the higher profile structures, which would take too long to become anaerobic and b) the polyethylene mesh allowed the tarpaulins to slip and be easily moved into the correct position so they could be joined together with minimal gaps. Most importantly, the tarpaulins will minimise the continuing physical damage to the wreck site and should further encourage anaerobic conditions on-site.

Each tarpaulin was deployed individually, with each end unrolled from the mid-section of the site. When all three tarpaulins were in the correct position they were joined together with cable ties through pre-prepared plastic eyelets and heavy duty nylon tabs. Sand bags were then tied in place along the seams and edges of the mats with previously installed nylon straps. Another layer of sand bags was then placed on top of these to minimise any gaps along the seams. Approximately 3-6 lines of sand bags were then placed along the bow and stern edges of the tarpaulin and another line of bags along the port and starboard side edges to seal any gaps and minimise water movement under the tarpaulin by strong currents and potential lifting by anchors. Finally, the entire interior of the tarpaulin was covered with approximately 1300 sand bags for added protection. The same procedure was followed for deploying the shade cloth and PVC tarpaulin ($2m^2$) over the off-site reburial depot.

Subsequent visits in March, September and November 2013, indicated that the *in situ* preservation strategy had been successful to date. All sand bags were still in place, there was extensive biological growth on the site and considerably more sediment build-up around the sand bags on top of the tarpaulins (Fig. 1). In addition, the sediment under the shade cloth was grey/black in colour indicating a low oxygen environment. The inspections showed that two of the higher profile ribs had broken through the protection and these will be wrapped in geotextile followed by impermeable black plastic. Any additional breakouts will be managed in the same fashion. Obviously, regular monitoring of any *in-situ* reburial strategy is essential in order to ensure continued long-term protection of the site.

James Matthews – *In-situ* Preservation

A comprehensive pre-disturbance survey and research into broader scale coastal processes and localised sediment level monitoring began in 2000. This work was extended in 2002 to assess the efficacy of sand bags, sediment trapping experiments using artificial seagrass and shade cloth mats and a cofferdam consisting of four environmentally inert, interlocking, medium density polyethylene 'road crash barrier' units (2m length; 0.9m height) filled with surrounding sediment, as site management methodologies. Long-term monitoring of the sediment to changes in micro-environment via microbiological and physico-chemical analyses were initiated (Richards et al., 2009).The crash barrier cofferdam technique appeared to be the best solution.

Preparations for this large-scale reburial commenced in April 2013 with a total of 22 personnel(AHSPP Chief Investigator and Acting Project Manager, Western Australian Museum staff, practitioners from Partner Organisations and volunteers) involved duringthe intensive five day fieldwork period from 18-22 November 2013.Personnel were divided into 2 to 4 smaller teams dependent on the activities of the day. The two main teams consisted of a land-based team, which filled 1400 x 20kg sand bags with clean, washed proprietary sand (20m^3 or 28 tonne) and the boat-based team, consisting of divers, boat handlers and support crew carried out all sea-based work on the wreck site. In addition two smaller teams were organised during the course of the fieldwork;a sand-barge team, which assembled and dismantled the sand barge and a shore-based team, which transported sand bags from the Museum to a beach about 100m from the wreck site and loaded the barge.

Fig. 2 Snorkelers sinking a RCB on the James Matthews site. (P. Baker)

Prior to the main program all previous site stabilisation equipment of anodes, sand bags and shade cloth were removed and a rope guideline was placed around the periphery of the site, which assisted in the 3 day deployment of the road crash barriers (RCBs), about 0.5-1.0m away from the wreck site in a semi-elliptical arrangement. Each RCB unit and connecting pin (0.9m length; 0.09m diameter) was filled with 20 kg and 5kg of blue metal (14mm), respectively on board a rented dive boat. The floating RCB and pin were then transported upright to the appropriate position on the wreck site using a small tender, then three snorkelers slowly sank the barrier via air displacement (Fig. 2). Two

Fig. 3 Plastic damp coursing anchored over the gaps between the RCBs with zinc tek screws. (J. Carpenter)

divers received the sinking RCB and the connecting pin and physically manoeuvred the barrier into the correct position, inside the guideline and then locked it in position with the pin. The RCBs weighed approximately 15kg under water and were easily manoeuvred on the seabed.

Following this procedure 36 RCBs were individually deployed on-site before they were permanently anchored in place with a minimum of 120kg of blue metal per barrier. The initial sealing of the gaps in the coffer dam with 2m long; 1m wide black plastic strips proved to be ineffective due to wave action across the site so they were replaced with high density, plastic roof damp coursing (450mm width; 500µm thick) about 1.5-2.0m in length, placed over the gaps and anchored flush against the inner surfaces of the RCBs with zinc alloy tek screws (Fig. 3).

Operation of the sand barge, designed to bring clean, washed sand to the enclosed wreck inside the RCB ring, proved that a beach based operation was not efficient since it involved multiple handling steps and took one day to deliver 3.5 tonnes of sand. The best method involved directly loading the barge from the rented dive boat moored adjacent to the site to minimise the distance the sand barge would need to be towed (Fig. 4).Twenty tonnes (1015 x 20kg bags) of sand was delivered to the site over the last two days of the fieldwork leaving8 tonne of sand at the Museum. The second phase of fieldwork was conducted over four days in early to mid-December 2013. By direct loading from the museum truck alongside the sand barge at the nearby Jervoise Bay Yacht Club, then towing the device to the wreck site a total of 8 tonne of sand was dumped on-site in one day with only 9 personnel. Dead seagrass that had begun to accumulate within the confines of the cofferdam was placed in bags and removed from the site.

A total of 165m^3 or 230 tonne of sand is required to achieve the desired 0.8m sediment height within the confines of the cofferdam. The enormity of this task became apparent after dumping28 tonne of sand which only produced a 5-15cm sterile sand layer. By deploying 4m wide strips of Armashade70% UV block shade cloth top over the top of the coffer dam it was hoped that the natural entrapment of fine sand particles suspended in the water column will assist in filling the cofferdam and also prevent ingress of dead seagrass. Seven panels with a 30cm overlap were sewn together with cable ties, which also enabled attachment to the RCBs (Fig. 5). In early 2014, the cofferdam will be filled to the required depth by dredging local surrounding sediment onto the site ensuring that minimal organic matter is incorporated within the backfilled sediment.

Fig. 4 Dumping of sand from the sand barge on the James Matthews site. (J. Carpenter)

Conservation Monitoring Programme

Pre-disturbance Surveys

The environmental characteristics of the pre-disturbed local burial environment should be assessed prior to reburial in order to assist in determining the inherent stability of the site and the major degradation mechanisms occurring on-site. In addition, this pre-disturbance information will be used as baseline data to assist in determining if and when the reburial environment returns to its original pre-burial state and the rate at which this occurs following the changes that necessarily accompany reburial. Analyses on both the *Clarence* and *James Matthews* sites included the chemistry of the seawater, pore water and sediments [pH; redox potential (E_{redox}); salinity, dissolved oxygen levels, total iron and organic content; sulphide and sulphate concentrations; nutrient (nitrogen and phosphorus)levels], the type and nature of the sediments (loss on ignition; particle size distribution; porosity) and the level and type of microbiological activity within the sediment. A 3,000km separation between the *Clarence* site and specialist microbiological assays in WA precluded microbiological analyses of those sediments.

It is also important to obtain an understanding of the extent of deterioration of the major material types present on a site prior to reburial. Moreover, it is essential to collect this baseline data for long-term comparative analysis to quantify the effect the mitigation strategy is having on the reburied materials. A full pre-disturbance corrosion survey [pH, corrosion potential (E_{corr}), total depth of concretion and corrosion (d_{total}), the total depth of corrosion (d_c)] was performed on the *James Matthews* site but no such survey was conducted on *Clarence* due to the lack of exposed metal objects. In addition, *in situ* pH profiles and pilodyn measurements were taken on exposed structural timbers on the *James Matthews* site, however only pilodyn data was collected from timbers on the *Clarence* site. Wood samples were collected from both sites for wood identification, maximum water content (U_{max}), microscopic and Fourier transform infra-red spectrometric (FTIR) analysis.

Fig. 5 The RCB cofferdam prior to the last length of shade cloth being deployed.(J. Carpenter)

Post Reburial Surveys

The biological and physico-chemical environment of the reburial mound should be monitored at regular intervals. Hence, the same suite of analyses will be performed on sediments recovered annually from the *Clarence* and *James Matthews* sites post reburial as was previously described for the pre-disturbed environment. However, since destructive sampling of reburied archaeological materials is inherently invasive, sacrificial modern samples, such as wood blocks and metal coupons, were included in the reburial mounds (Fig. 6).

Fig. 6 The sacrificial wood and iron samples on the Clarence site prior to reburial.(J. Parkinson)

Sacrificial wood samples and modern ferrous alloys were reburied on both wreck sites. There were significant amounts of copper alloys (e.g. fastenings, sheathing, etc) present on the *James Matthews* site, therefore duplicate copper alloy coupons were also reburied on-site. One of the duplicate wood, iron and copper sacrificial samples were wrapped in Bidim A14 geo textile to ascertain its protective effect on reburied artefacts. Each set of samples had to be reburied at least 1m apart to ensure there would be no influence of the metal corrosion products on the degradation of the wood samples and to minimize proximity corrosion.

The sacrificial samples will be recovered and analysed annually. The same suite of *in-situ* and *ex-situ* analyses will be performed on the samples post reburial as was previously described in the pre-disturbance surveys. However, additional analyses [i.e. weight loss, scanning electron microscope/energy dispersive x-ray analysis (SEM/EDAX) and x-ray diffraction spectroscopy (XRD)] will be performed on the metal coupons. The results of the biological and physico-chemical analyses of the sediments can then be correlated to the extents of deterioration of the sacrificial samples and extrapolated to the condition of the reburied archaeological material.

Conclusions

One of the major aims of the AHSPP is to develop a protocol for the excavation, detailed recording and reburial of historic shipwrecks under threat by anthropogenic or natural forces. On-site monitoring of the sediment and analysis of sacrificial samples on the *Clarence* and *James Matthews* sites will continue until early 2015to test the efficacy of different reburial and stabilisation techniques and provide a comparative analysis of practical protocols. This work will be critical to the future development of national policy, methodology and technical guidelines for *in-situ* preservation and management of endangered historic shipwrecks.

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Biography

Vicki Richards *has been a Conservation Scientist in the Materials Conservation Department of the Western Australian Museum for the past 27 years. One of her primary research areas is devising and implementing appropriate on-site management plans for the long-term in-situ preservation of shipwreck sites*.

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