CURRENT APPROACHES TO THE UNDERWATER CULTURAL HERITAGE - STRENGTHS AND WEAKNESSES.
MATERIALS CONSERVATION MANAGEMENT.

Ian MacLeod, Department of Materials Conservation,
Western Australian Maritime Museum, Fremantle.

Protecting and Conserving Underwater Heritage

When we Australians look at the perspective of maritime heritage in Britain we traditionally associate it with the national authorities and the glory of the collections of the Royal Observatory in the National Maritime Museum in Greenwich, or the ancient harbour at Portsmouth from whence the First Fleet set sail. Yet surprisingly, in the United Kingdom there is scant protection for conserving the wonderful maritime heritage of that country, because, as Graeme Henderson pointed out in his speech, the conservation management of the archaeological sites until recently fell under the Department of Transport, and there is a requirement that after archaeological examination the material, the artefacts, the very history itself must be sold to recover costs.

Now this is hardly an environment for maximising the cultural heritage that belongs, not just to that country, but to the world. You have a situation where it is either by chance encounters or the likelihood of Royal support for projects like the Mary Rose - which nevertheless is still privately funded and not supported by government - that will see the coming-to-age of the heritage preservation movement. A case in point is the Tower of London, where they have a magnificent collection of arms and armament. In the conservation laboratories there I saw a wonderful cast-iron cannon, on which was the cipher of the Commonwealth of England. The arms are conjoined shields with the flag of St George and the harp of Ireland. After the Civil War, Oliver Cromwell was going around 'sticking his monogram on the ordnance' that he was casting. The Tower of London was able to purchase it for a couple of thousand pounds and have it conserved. It has now gone on display after treatment with the alkaline sulphite method developed by Neil North. It is the only remaining cannon of its type, since after the restoration of the monarchy all the ordnance relating to the Commonwealth was destroyed. The point is that this was just a chance encounter of a Dutch seaman, who happened to recover the cannon in his trawling nets, with this only remaining example of an iron cannon of that period. It is fortunate that it has now been preserved, and I am sure that there are many other cases where artefacts have not had such a fortunate fate.

When you look at the situation of recovery of archaeological iron objects in countries like the Philippines, we see (figure 1) an example of the material recovered that was not treated. This magnificent iron cannon that once bore the ciphers showing that it dates from the early Spanish colonial period, has now lost all that surface detail because it wasn’t properly conserved. One of the real issues facing heritage preservation of the material on the seabed is the natural curiosity of the archaeologists, who, on finding a concreted cannon, can’t control themselves, and they must raise it to the surface, wack the concretion off and get a photograph of it, and say ‘whooppee!, look what I have found’. This should be contrasted with the much more responsible and systematic approach adopted in other countries like Australia, where the material is only recovered after careful consideration, and then only when there are appropriate conservation treatment facilities either on-site or within a short distance, so that the artefact, which is in a precarious state after its recovery from the seabed, can be placed in a stable environment.
It is also important to remember that even treated artefacts, when they go on display, are still prone to deterioration. For corroded cast-iron objects it is essential that even after conservation treatment they be displayed indoors. Otherwise the natural expansion and contraction of the consolidating resins and stabilising chemicals will allow ingress of moisture, as a result of a combination of UV radiation and diurnal variation of temperature and humidity. Once the protective barriers have been penetrated, the corrosive agents once more can reach into the heart of the object and so lead to its ultimate corrosion and decay.

**Documentation**

It cannot be stressed strongly enough the importance of careful archaeological documentation during an excavation. That documentation consists of not only recording of divers’ notes on underwater slates but also photogrammetric work and, more recently, the recording of the site and the activities using underwater video.

An example of the significance of such documentation, as regards the depth of the sediment covering the material is found on the wreck of the American China-trader *Rapid*. Two halves of an identically cast bronze bearing for the capstan were found to have very different patinas. One of them had a roughened mottled surface, while the other seemed to reflect a patination of the original as-cast surface. Ultimately, we found in the case of this bronze bearing, as indeed was the case of several keel straps on the site, that the depth of burial on the site has a pronounced effect on the corrosion mechanism. Objects lying proud of the seabed get preferential attack on the copper-rich phase of the alloy, whereas those lying under some sediment, where the amount of dissolved oxygen is lower, get preferential attack on the thermodynamically more reactive phase, which contains the tin lead and the antimony and all the other less noble elements. The new result was that 8 times more chloride ions went into the object that had been lying under about 15cm of sediment when compared to the one lying proud on top of the seabed. Without the archaeological record it would have been impossible to correlate this very curious phenomena. Not only did it help solve a conservators riddle, but it also helped explain other degradation problems on the site.

![Fig. 1 A corroded 17th Century cannon from a Spanish wreck in the Philippines - the result of no conservation treatment.](image)

**Systematic Recovery**

Once conservators and archaeologists are made aware of such issues it not only provides an excellent incentive for detailed documentation, but it also gives the hope for understanding this susceptibility of the objects to further deterioration.
One of the things that differentiates systematic maritime archaeology from the wreck plundering that is commonly practiced in many parts of the world is that the plunderers tend to grab the whole and the complete objects, and raise them and ultimately sell them off at auctions. However, at the sites excavated by the Western Australian Museum it was the systematic recovery and the sifting through of concretion instead of woofing all the debris up the airlift. Once the fragments and sherds were sorted, the conservator was able to match the exterior surface and the body of the ceramic and put it together to form the complete vessel (figure 2). It took more than 56 fragments to recreate an almost complete object.

This is a lovely cobalt-blue-glaze, originally pewter-lidded, jug, which bears the arms of the City of Amsterdam. It tells a wonderful story of not only the conservation work that goes into the recovery and the refurbishment of such items, but the very fact that it was brought together from so many scattered bits tells the story to the public that real benefits can be obtained from systematic archaeological excavations, whereas in its fragmented state the story of this jug could never be told.

Recovery of ships’ timbers from estuarine mud deposits or in sandy waters reveals apparently well preserved material. After some preliminary conservation the objects may appear to be quite stable and in a good displayable condition. A case in point is that of one of the Balanghay edge-pegged vessels of the 12th century on display in the National Museum in Manila, in the Philippines. The object had been on display for a period of 8 years and there was essentially no climate control in the building, since the air conditioning plant had been broken down for long periods. However, when the timbers were closely examined, (as details show in figure 3), the surfaces were mottled and coloured with yellow and white growths representing outgrowths of sulphur, FeSO\textsubscript{4}·H\textsubscript{2}O and acidic iron corrosion products. The surface pH of some of these timber sections was as low as 1.8 and this resulted from oxidation of the iron sulphides in the timber to form iron sulphates, which further oxidize the sulphur up to sulphuric acid in conjunction with molecular oxygen and the high level of humidity.

![Fig.2a](image1.jpg) **Fig.2a** Fragments of the Vergulde Draeck (1656) jug prior to restoration.

![Fig.2b](image2.jpg) **Fig.2b** Reassembled jug from Vergulde Draeck (Photo by Jon Carpenter).
It is possible to overcome the problems of the acidity and retreat some of the timbers, but with proper care and conservation, and a commitment to maintenance of a stable environment, such problems can be avoided. I think it is very important at this stage to state that such problems aren't necessarily the preserve of so-called under-developed nations, because we had exactly the same problems with some of the batches of the first treated Batavia timbers. However, we have been monitoring them since we gave them a gaseous ammonia treatment, to neutralise the acidity, and over the past four years there has been no systematic shift in the surface pH of the treated timbers. Eternal vigilance must be the watchword.

Research
With the detailed documentation of an archaeological deposit it is possible to 'go back in time' and use the notes about the position of objects on the site. This is necessary because it is always impossible to know all the questions about the nature of the site while you are on it. It is often only when you are dealing with the objects and treating them that problems of different degrees of degradation of the wood become apparent. For example we need to look at the interactions of the degradation of the wood products with the metal corrosion products and vice versa. Many of these questions only come to the mind of the conservators who are dealing with the objects, so then they need to go back to the archaeological record, and if this is poor in terms of registration details, location of objects and site profiles, you are never able to get the proper answers to questions. It needs to be stressed that although the stabilisation of waterlogged wood has been well studied for the last twenty years there is still a long way to go to obtaining an easy method whereby the degree of degradation of such timbers can be readily gauged and the optimum treatment programme worked out. Large structural timbers are conserved by impregnating them with polyethylene glycol. The function of the PEG is to replace the water that has entered the degraded wood as a result of microbial activity chewing away at the cellulose, holocellulose, pectins and other easily digestible components of the wood. As they eat, the void left behind after the destruction of those structural materials is filled with water. If the timber is allowed to dry under uncontrolled conditions it will simply distort and crack and face utter collapse and ruination.

One point to note is that we have found it totally unnecessary to establish stainless steel heated treatment tanks for the impregnation of polyethylene glycol into the timbers. Although our mild steel treatment tanks suffer initial corrosion the rate falls off as the concentration of PEG increases, and as the amount of time in which the wood is being desalinated and soaked and the solution increases. This is because a lot of the tannins and related materials that are natural corrosion inhibitors for iron are extracted. These tend to passivate those surfaces of metal treatment tanks. The cost savings are tens of thousands of dollars.

It is important to have access for research purposes to the artefacts. When we look at the case in point of examining the metallographic structure of some copper bolts from the James Matthews, we can see the way in which the heads of the nails have been cold-worked. There is extensive distortion shown in the microstructure, and this tells something of the technology that was not recorded in France, when the vessel was being built in the 1820-1830's. More importantly, the chemical analysis, combined with the microstructure of these fittings, has shown that they have a high bismuth impurity level. It is this high level of bismuth, particularly in some objects when combined with high levels of nickel and arsenic impurities, that has given us the information that led to the identification of the source of copper ores used by the French in the manufacture of the nails used in the original construction of the James Matthews. One very important effect that bismuth has on the strength of copper alloys is that it makes them subject to cracking. So it was that when the James Matthews was driven upon the shore the grinding and wearing of the hull against the sandy bottom caused the copper spikes and bolts in the hull to be worked, and the high bismuth content meant that they cracked and many of them sheared off. This of course opened up
the vessel and ruined any chances that the early settlers had of recovery of the ship or their belongings. Here is a case where the metallurgical microstructure and chemical composition have helped the archaeologist rationalise and understand why it was that this otherwise sturdy seagoing vessel came to grief upon the shore of Cockburn Sound in 1842.

**Preservation of Iron Shipwrecks**

The iron ship was responsible for an enormous advance in the amount of trade and transportation of people to and from Australia. It is a natural consequence of the abundance of such vessels on our shores that a large number of them ended up as shipwrecks. Whilst the whole of wooden vessels buried under the sand slowly degrades, and even in its waterlogged conditions can last in its original shape for many hundreds of years the situation is not the same for iron wrecks. Once they are concreted, that is, covered with a calcareous marine growth, they will continue to corrode, albeit at a slower rate than that originally dictated by the deposition of the vessel into the benthic environment.

One consequence of the fact that iron continues to corrode whilst on a shipwreck site is that the iron wrecks are in fact a diminishing archaeological resource. Thus serious thoughts need to be given to the in-situ preservation of such items, for the benefit of either recreational activities or for study by future generations.

The work has been pioneered on the wreck of the steamship *Xantho* at Port Gregory. Similar studies have been carried out on wreck material from the site of HMS *Sirius* on Norfolk Island, resulting in the recovery of the best preserved anchor from an 18th century wreck in Australian waters. The waters on the *Sirius* wreck site at Norfolk Island are very shallow, subject to high levels of surf and fully oxygenated, making it one of the most aggressive shipwreck sites in Australian waters.

This in-situ conservation approach means we have a new hope on the horizon where through study at a predisturbance level of iron wreck sites it is possible, with collaboration between conservators who understand their electrochemistry and maritime archaeologists who understand conservators, to get optimum results for a site: namely preservation for the benefit of future generations.

Figure 4 shows a systematic map of the corrosion potentials of the wrought iron and cast iron fittings on the SS *Xantho*, prior to recovery of the engine. The next view (figure 5) shows you the engine halfway through its electrolysis treatment in a specially built tank. One of the factors that led to the recovery of the engine was that the underwater drawings by Geoff Kimpton unequivocally demonstrated that it was a horizontal trunk steam engine. As such it was the world's only surviving example of that type of engine, so the archaeological decision was made to excavate. Prior to the recovery of the engine, corrosion studies were performed, and were carried out immediately after, and at intervals of 18 and 48 months. Eight years after the recovery of the
engine, the measurements have shown that there has been no significant change in the corrosion nature of the site through the intervention that resulted in the recovery of this glorious 5-tonne bit of marine steam engine technology. Currently on the site there are two sacrificial zinc anodes attached to the stern section in six places. Previous work on the engine, during temporary protection prior to its recovery, had clearly demonstrated that although better power is obtainable from aluminium anodes, these do not work when they are covered by several metres of sand. Since the Xantho site is subject to periodic burial and exposure under several metres of water, it is essential to use zinc rather aluminium anodes.

Surveys of corrosivity have been carried out on historic iron shipwrecks in Port Phillip Bay, and even at the same water depth the water movement is a major factor in determining the corrosion rate. If we compare the performance of the iron on the wreck of the City of Launceston, stuck plum in the middle of Port Phillip Bay, with that of the Eliza Ramsden sitting right in the shipping channel at the mouth of the Rip, the difference of the corrosion potential is in the order of 100mV at the same water depth of 22m. But measurements on the hull thickness, and even casual observation of the state of preservation of the wreck, convinces one that there is approximately a tenfold difference in the corrosion rate of these two iron wrecks, in the same biological zone and water depth. It is difference in water movement that causes the difference in corrosion rate.

Finally, I want to make a case for archaeological intervention on historic shipwreck sites. It is only through the systematic recovery of material from such sites that the life and times of ordinary people is going to be recorded. Consider the state of a concreted pewter ewer from the Zuydorp, as it was recovered and after conservation treatment. When heated it showed us the pewterer’s mark on its base. Correspondence with historians at the Rijksmuseum in Amsterdam told us that the Tiffenau stamp referred to a Jacob Tiffenau, who was one of the family of pewterers who lived in the Netherlands in the early 18th century. They even had records of who this person had married, and what his family had gone on to do. Thus we go and find not only a wonderful example (and for the Dutch they were delighted and shared in rejoicing in this new found heritage), but the angel (figure 6) on this stamp has shed forth its marvellous light of discovery and understanding of heritage shared, and new hope and vision for the future. Through proper management of our maritime archaeological heritage, the lives, times, energies and the efforts of people in past generations have a chance of being preserved, rediscovered and retold to the countless generations that lie ahead.