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The Protection of the
Underwater Cultural Heritage

UNIT 11

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Conservation and Finds Handling

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Conservation and Finds Handling

Core Knowledge of the Unit

This unit provides students with an understanding of on-site conservation processes, including object recovery and first aid for finds. Students will also become aware of long term issues related to object recovery and ethical differences between conservation and restoration.

Upon completion of the Conservation and Finds Handling unit students will:

- *Understand the ethical and financial responsibilities/obligations placed on archaeologists if they want to raise objects from an archaeological site*
- *Have knowledge of different material types preserved in a maritime environment*
- *Have insight into materials and their deterioration* in situ *and within a museum collection storage and display context*
- *Have knowledge of a range of methodologies for lifting materials*
- *Be aware of a range of first aid procedures for underwater finds*
- *Have examined a range of case studies*
- *Be able to discuss the ethical and practical differences of conservation versus restoration*

Introduction to the Unit

The overall aim of the 2001 UNESCO Convention is to encourage the responsible protection of underwater cultural heritage, with a special focus on *in situ* preservation. Although finds handling implicitly focuses on the lifting of objects, both the International Committee of the Underwater Cultural Heritage (ICUCH) and UNESCO realize that excavation is an important part of underwater cultural heritage management. It is, therefore, necessary for students to have an understanding of *in situ* and *ex situ* conservation, so that they may appropriately protect sites and handle finds should they be recovered.

While *in situ* preservation is dealt with extensively in Unit 9: *In Situ Preservation*, it is necessary to include aspects of this knowledge into the context of this unit, yet primarily focus on creating an understanding of materials, how they deteriorate and first aid for finds from the marine environment.

'Conservation is part and parcel of archaeology; without it much archaeological information is lost or left unexploited' (Cronyn, 1990)

1 Conservation

1.1 Conservators

To begin understanding conservation, we must first understand what conservation is and what it is that conservators do.

The Heritage Collections Council, in their publication *reCollections: Caring for Collections Across Australia*, (1999) provides a definition of conservation that states,

> *Conservation; seeks to halt the deterioration of an object using chemical or physical means that are ideally reversible. Its purpose is to study, record, retain and restore the culturally significant qualities of an object with the least possible intervention.*

Alternatively, conservation-restoration, also referred to as conservation, is a profession devoted to the preservation of cultural heritage for the future. Conservation activities include examination, documentation, treatment and preventive care. All of this work is supported by extensive research and education.

The traditional definition of the role of the conservator involves the examination, conservation and preservation of cultural heritage using 'any methods that prove effective in keeping that property in as close to its original condition as possible, for as long as possible'.

However, today the definition of the role of conservation has widened and would more accurately be described as that of ethical stewardship.

The conservator applies some simple ethical guidelines, such as:

- *Minimal intervention*
- *Appropriate materials and methods that aim to be reversible and to reduce possible problems with future treatment, investigation and use*
- *Full documentation of all the work undertaken*

The conservator should aim to take into account the views of the stakeholder and to apply their professional expertise accordingly.

Critical points are those of minimal intervention and reversibility, though the ideal of the latter is not always achievable in reality (for example, the *Mary Rose* or *Vasa* removal of Polyetylene glycol (PEG) treatment). All treatments impose a certain degree of alteration to wood. With PEG treated wood, the wood's appearance can change and darken. The wood can take on a waxy appearance if too much PEG has been applied. With archaeological wood that is impregnated with iron corrosion products or still has iron pins or bolts *in situ*, this material usually contains unstable sulphides which can oxidize to sulphates and eventually to sulphuric acid (Sandstrom *et al*, 2002). This leads to the destruction of the timbers.

Conservators are specialists who employ a range of chemical and physical techniques to achieve the preservation of objects. These techniques are selected by conservators based on their knowledge of the materials used in the artefacts construction, the deterioration process of that material in a particular micro-environment and the science behind methodologies used to achieve stability.

Conservators are typically trained at university level and their course requires them to study a significant component of chemistry, which ideally includes analytical chemistry. Many conservators specialize in a range of disciplines. These can be Paper, Paintings, Textiles, Photographic/Digital Media and Objects. Objects are usually broken down into a further range of sub-disciplines that can be split on material lines, such as organic or inorganic. Within inorganic objects, conservators can further specialize into ceramics and glass, iron, copper/alloy or large objects (sculpture or working machinery). Equally, conservators specializing in organic objects can become specialists in areas, such as bark paintings or wood.

Conservators can also specialize in other ways. Some conservators focus on being preventive conservation officers, looking at preserving collections through the management of the environment within buildings. In regards to this unit, some conservators specialize as archaeological objects conservators. Unlike other conservators, archaeological objects conservators need to be competent and capable of dealing with all material types and must equally be focused on the task of preserving the object. This includes the collection of information from the excavated artefact that will add to the pool of interoperable data from the site.

Suggested Reading

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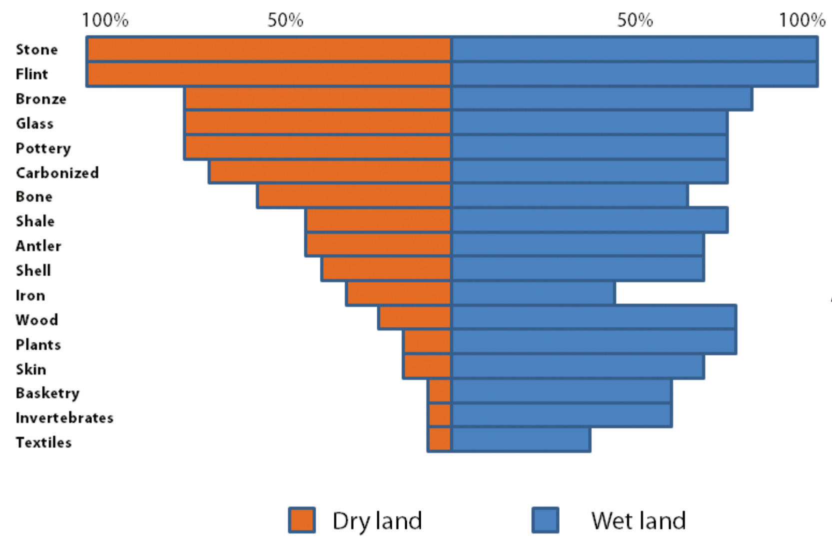
1.2 Deterioration

The susceptibility of a material to deterioration varies according to the nature of the material and its immersion environment. Key factors include:

- *Material composition*
- *Water composition (oxygen and mineral content)*
- *Extent of water movement*
- *Composition of the burial environment*
- *Depth of burial or submersion*
- *Temperature*
- *Development of encrustation*
- *Position and relationship to other materials*
- *Period of immersion*

For archaeologists working in a maritime and underwater environment, the potential for organic finds is significantly higher than that on land. The reason for this is mostly environmental, though the effect of reduced human activities on underwater sites has a very significant impact. For an object at a micro-environmental level, this translates to reduced physical abrasion and mechanical action, reduced anaerobic environmental conditions and a depth of burial that limits or totally precludes access by a marine organism.

An indicative comparison of the preservation of materials on European dry land and wet land sites



Drawing of an indicative comparison of the preservation of materials on European dry land and wet land sites. © Andrew Viduka after Coles, 1988, fig 5

This chart shows the differences between how well materials are preserved in both dry and wet land environments.

1.2.1 Treatments

Treatments that are carried out on objects by conservators are known as remedial or interventive conservation. Treatments are primarily implemented when objects are so unstable that they cannot be successfully kept in perpetuity through preventive conservation management alone. Interventive treatments are carried out based on a number of criteria, the most important of which are: the significance of the object from an archaeological context, the level of conservation required to stabilize the object and what type of storage or display environment the object will end up in. Selected treatments are, as stated earlier, ideally reversible.

1.2.2 Conservation System for Prioritization

The conservation of objects is predicated on their chemical and physical stabilization, however, archaeological material does not always warrant treatment and in some cases no conservation or the most minimal conservation treatment is awarded. For example, large quantities of ceramic or glass excavated from a particular site may simply be cleaned to facilitate assessment and documentation prior to bagging, storage or backfill. Prioritizing treatments allows us manage and reduce costs in the post excavation process and can potentially allow research findings to be published more quickly. To achieve this, treatment planning must take into consideration the utility of the archaeological object for chemical analysis, typological, historical research or display, within the framework of answering archaeological questions. This helps to maximize both the effectiveness and efficiency of the conservation laboratory. Careful planning using guidelines provided by MoRPHE or Phase III of Management of Archaeological Projects (MAP2 English Heritage) can provide an assessment of potential for analysis.

For more information see English Heritage: http://www.eng-h.gov.uk/guidance/map2/map2-6 htm#sect6 (Accessed February 2012.)

Due to the sheer volume of objects that can be recovered from a site and the need to rapidly analyse objects for interpretation and publication, artefacts from an excavation may be divided into five categories. These categories are outlined by Janey Cronyn in her book *Elements of Archaeological Conservation* and included within guidelines published by the United Kingdom Institute of Conservators Archaeological Section (UKIC Archaeological Section, 1982). They are as follows:

1 Display conservation: *further cleaning, additional restoration and cosmetic treatment may be required in addition to category 2.*

2 Full conservation: *work is understood to include photography, X-radiography, examinations and investigation, cleaning, active stabilization and certain reconstruction. Appropriate analytical information to be provided where required.*

3 Partial conservation: *will include work in category 4 and a high degree of cleaning with or without active stabilization. This category may include reassembly of broken or detached fragments, but not reconstruction of missing areas.*

4 Minimal conservation: *this category includes 'first-aid', X-radiography and photography, the minimum amount of investigative cleaning, and suitable packaging or repacking for stable storage.*

5 No conservation: *no work of any kind is undertaken by the laboratory except for handling and checking. (Cronyn, 1990, pp. 12.)*

For finds from a marine environment, no conservation is not a realistic option, unless rapid reburial in a marine environment is planned. Duty of care requires that to achieve the minimum conservation standards, the objects must have soluble salts removed before they are repacked for stable storage.

1.2.3 Collaboration

Throughout the process, conservation must be considered an archaeological project designed to maximize outcomes that preserve artefacts and reveal information. It is also important in terms of recognizing the ongoing financial commitment that institutions have to make.

These commitments cover all stages of the conservation process, including planning, excavation and finds handling, condition assessments, prioritizing and undertaking treatments, storage and display, ongoing monitoring, maintenance and additional conservation treatments.

Collaboration in conservation is the only ethical approach. Without it information is lost and time is wasted. The collaboration must be between all those who have interest in the excavated archive, such as the excavators, finds specialists, curators, analytical scientists, and conservators (Cronyn, 1990, pp. 10).

On-site care of finds requires the cooperation of everyone, from the site director to the first season diggers. Artefacts need to be properly treated from the moment of exposure, until their arrival at the conservation laboratory. Thus it is important that transport to the laboratory, as well as stabilization, lifting, restricted cleaning and packing is catered for (Cronyn, 1990, pp. 10-11).

1.3 Conservation Versus Restoration

1.3.1 Restoration

1. The act of restoring or state of being restored, as to a former or original condition, place, etc.
2. The replacement or giving back of something lost, stolen, etc.
3. Something restored, replaced, or reconstructed
4. A model or representation of an extinct animal, landscape of a former geological age, etc.

1.3.2 Conservation

Conservation is about preventing damage and loss to our cultural heritage. Conservation aims to minimize change to collection material, protect items from the adverse effects of climate and chemical deterioration, and to safeguard our heritage not only for ourselves, but for future generations.

Conservation activities may include preservation, restoration, examination, documentation, research, advice, treatment, preventive conservation, training and education.

The term 'preservation' refers to the protection of cultural property through activities that minimize chemical and physical deterioration, such as improved storage conditions and environmental control. The primary goal of preservation is to prolong the existence of cultural material.

'Restoration' involves treatments that enhance the interpretation of cultural heritage, for example, inpainting losses in an oil painting so that the original appearance of the image is maintained. Restoration may also involve the reassembly of displaced components, removal of extraneous matter or integrating new materials or components, in order to stabilize and strengthen the original artefact.

Even when performing restoration work, conservators choose methods of 'minimal intervention', focusing on stabilization and retaining the original material. Conservators also use materials with good ageing characteristics and, where possible, select treatment methods that are reversible. Conservators also document the condition of an object through written reports and photographs, both before and after treatment, in order to retain records of what has been changed for future owners and caretakers.

Unlike conservation which strives for minimal intervention and reversibility of interventive methods, the aim of professional restoration is to return or restore an object back to its original appearance. This often involves what conservators would deem 'destructive', non-reversible interference with the object.

Another illustration of this debate can be found in ceramic conservation. For display purposes, there can be a desire for an object to be made 'whole' by filling gaps completely with plaster. From an archaeological perspective, the object only requires fills if the object needs to be built up for display and/or study, and even then, the fills only need to be structural, so that the object does not collapse. Consequently restoration creates the potential for imposing an interpretation on an object that may not have otherwise existed.

1.3.3 Definitions by International Council of Museums (ICOM) – Committee for Conservation (CC)

ICOM-CC has adopted the following terms: 'preventive conservation', 'remedial conservation' and 'restoration' which together constitute 'conservation' of tangible cultural heritage. These terms are distinguished according to the aims of the measures and actions they encompass.

Blue transferware bowl after conservation and restoration, HMS Pandora *artefact. © Queensland Museum*

The definitions of the terms are as follows:

1 **Conservation:** all measures and actions aimed at safeguarding tangible cultural heritage while ensuring its accessibility to present and future generations. Conservation embraces preventive conservation, remedial conservation and restoration. All measures and actions should respect the significance and the physical properties of the cultural heritage item.

2 **Preventive conservation:** all measures and actions aimed at avoiding and minimizing future deterioration or loss. They are carried out within the context or on the surroundings of an item, but more often a group of items, whatever their age and condition. These measures and actions are indirect – they do not interfere with the materials and structures of the items. They do not modify their appearance.

Examples of preventive conservation are appropriate measures and actions for registration, storage, handling, packing and transportation, security, environmental management (light, humidity, pollution and pest control), emergency planning, education of staff, public awareness and legal compliance.

3 **Remedial conservation:** all actions directly applied to an item or a group of items aimed at arresting current damaging processes or reinforcing their structure. These actions are only carried out when the items are in such a fragile condition or deteriorating at such a rate, that they could be lost in a relatively short time. These actions sometimes modify the appearance of the items.

Examples of remedial conservation are disinfestation of textiles, desalination of ceramics, de-acidification of paper, dehydration of wet archaeological materials, stabilization of corroded metals, consolidation of mural paintings, removing weeds from mosaics.

4 **Restoration:** all actions directly applied to a single and stable item aimed at facilitating its appreciation, understanding and use. These actions are only carried out when the item has lost part of its significance or function through past alteration or deterioration. They are based on respect for the original material. Most often, such actions modify the appearance of the item.

Examples of restoration are retouching a painting, reassembling a broken sculpture, reshaping a basket, filling losses on a glass vessel.

Conservation measures and actions can sometimes serve more than one aim. For instance, varnish removal can be both restoration and remedial conservation. The application of protective coatings can be both restoration and preventive conservation. Reburial of mosaics can be both preventive and remedial conservation.

Conservation is complex and demands the collaboration of relevant qualified professionals. In particular, any project involving direct actions on the cultural heritage requires a conservator-restorer.

See ICOM-CC's The Conservator-Restorer: a Definition of the Profession and ICOM's Code of Ethics for Museums: www.icom-cc.org/242/about-icom-cc/what-is-conservation/ (Accessed February 2012.)

2 Materials: Their Deterioration and Conservation

As the aim of this unit is to broadly introduce students to conservation and not make them into conservators, it is inappropriate to include detailed information related to materials and their deterioration. It is, however, important that students understand a little about the materials being treated, so that any first aid treatment that is undertaken on an artefact is selected on informed principles.

As Robinson very correctly points out, this is crucial because some materials may respond well to one type of treatment, while others will not, and if a find has potential for scientific analysis or dating, special treatment (or no treatment at all) might be required. Knowing the particular risks a find might be subject to and how quickly it can be expected to change, will enable the prioritization of treatments and arrange first aid processing to make best use of time and resources (Robinson 1998, pp. 23).

To illustrate materials, their deterioration and conservation this unit will draw upon examples of finds from HMS *Pandora*.

Case Study 3

HMS *Pandora*

Background

HMS *Pandora* (1791) was a 24 gun frigate sent to pursue the H.M.A.V *Bounty*. The vessel sailed extensively throughout the Pacific at a time when the concept of museums was just beginning, in the form of gentlemen's curiosity cabinets. Objects were collected either directly or by proxy, at a time when social advancement was often connected to patronage. The HMS *Pandora* was unsuccessful in its mission to capture all of the HMAV *Bounty* mutineers and was eventually wrecked in Far North Queensland while trying to navigate through the outside edge of the Great Barrier Reef. The Queensland Museum conducted a number of expeditions to the site; the last excavation was carried out in 1999.

2.1 Inorganic Objects

2.1.1 Stone, Ceramic and Glass

The archaeological excavations conducted on the wreck site of HMS *Pandora* recovered a vast amount of inorganic objects. These objects provide a unique insight about life on board the ship, some of the landfalls of the HMS *Pandora* crew during the search for HMAV *Bounty* mutineers and information about the ship itself.

Some of the objects that have been recovered include:

- *Buttons*
- *A watch*
- *An ink well*
- *Drinking glasses*
- *Dinner plates*
- *Sea shells*
- *Poi pounders*
- *Stone adze heads*
- *Intaglio seals*

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The conservation of inorganic materials can be achieved by a number of different methods. The chosen method is usually selected because of the condition of the object, the conservator, the time available, the equipment and materials available to work with, and the final storage or display environment.

There is no one fixed approach to object conservation, though a conservator may prefer one method over another. Inorganic maritime object conservation primarily focuses on the removal of chemically-free (not bound in a reaction) chloride ions from the artefact, generally termed as 'salts'.

Dripstone from HMS Pandora.
© Queensland Museum

Most objects recovered from a marine environment will rapidly degrade in air if no effort is made to remove these salts from the object.

The general treatment processes for both ceramic and glass artefacts may involve deconcretion, stain removal, desalination, rejoining and gap filling (where structural losses exist). Following the completion of the desalination treatment, further chemical degradation of ceramic and glass objects can be controlled by storing them in environmentally stable conditions. Stain removal, assembly and gap filling are only required when they contribute to archaeological interpretation or display. In addition, if the delicate nature of these objects is a concern, specialized display packing or supports are usually required.

Poi pounder from HMS Pandora.
© Queensland Museum

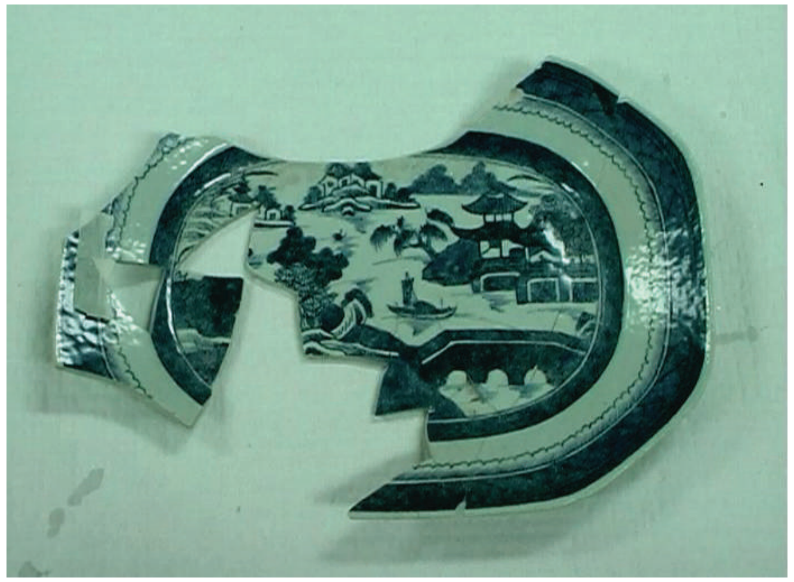
In a marine environment, soluble salts can enter and chemically react with ceramic and glass objects. These salts need to be removed before drying as they will cause the deterioration of objects in air. If soluble salts have entered into the body of an object they cause significant physical damage through a process known as deliquescence. The damage caused by deliquescence is irreversible, leading to cracking and lifting of glazes, or cracking and flaking of the ceramic or glass body itself. Soluble salts are easily removed by washing the object in successive baths of fresh water. The salt levels are usually monitored by conductivity measurements. Desalination is continued by simply changing water baths until the salt levels remain constantly low.

Alkali leaching is the major form of chemical degradation for glass. In a marine environment, this process is significantly faster than in ambient conditions. Glass that has deteriorated in this manner is easily recognised by an iridescent, flaky surface that is often easily damaged by handling. This process can continue out of water if relative humidity levels fluctuate and can be recognised by the presence of 'sweat' droplets on the surface of the object.

One example is a transfer printed earthenware dish from the HMS *Pandora* which was discovered as pieces embedded in the concretion, adjacent to a six-pounder cannon. The pieces were separated from the concretion mechanically using a pneumatic drill and dental tools. Vestiges of concretion that remained adhered to the surfaces were removed chemically with an acidic solution to avoid mechanically damaging the fragments.

Some staining which had occurred from contact with the corroding iron cannon, was 'removed' using a bleaching agent. Chelating agents, such as Ethylenediaminetetraacetic acid (EDTA) or oxalic acid can also be used to remove organic and inorganic stains.

Once desalination was completed and the ceramic pieces dried, the pieces were reassembled using a reversible acrylic adhesive. The plate was then in-filled with plaster of Paris to provide structural support and to achieve an aesthetic finish.



Blue transferware plate from HMAV Bounty, Pitcairn Island excavation, undergoing conservation. © Queensland Museum

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Sandstrom, M., Jalilehvand, F., Persson, I., Gelius, U., Frank, P. and Hall-Roth, I. 2002. Deterioration of the Seventeenth Century Warship *Vasa* by Internal Formation of Sulphuric Acid. *Nature*, Vol. 415, pp. 893-901.

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2.2 Metals

2.2.1 Iron

For metals, washing an object free of salts is a significant step towards stabilization, however, most metals also require a corrosion inhibitor and coating systems to further promote stability. The corrosion inhibitor locks up metal ions that could react with the environment to form stable corrosion products. The coating system impedes the access of oxygen and water to the metal surface, which limits the rate at which corrosion can occur. Depending on the material and its condition, other steps may be needed before an artefact is exhibited, stored or studied.

An example of a metal object that was conserved utilizing this methodology was a gun from the HMS *Pandora*. The HMS *Pandora* as a 24 gun frigate was armed with three types of cast iron gun: six pounders, eighteen pounders and swivel guns (half-pounders).

A six pounder gun was selected for recovery after an *in situ* assessment of its condition revealed that the gun was suitable for conservation. Assessment involved measuring the depth of corrosion and the thermodynamic state of the object. This data, when combined with other site specific information, enabled an appreciation of the object's rate of annual deterioration to be determined.

The gun was winched onto the back deck of the work boat and then registered and packed wet for the return boat trip to Townsville. It was vital for the conservation treatment process that the gun did not dry out during transport, as new corrosion would increase the chances that the gun's surface which holds all the historical detail, such as foundry markings, would later disbond during or after treatment.

Concreted six pounder gun from HMS Pandora *on a treatment cradle. © Queensland Museum*

Upon arrival at the Museum of Tropical Queensland, the gun was documented in detail, drawn and photographed, before mechanical deconcretion was started.

It was not possible to acquire an X-ray image of this six pounder gun, but an X-ray image of a much smaller half pounder swivel gun was acquired, in part to get a general understanding of the corrosive nature of the microenvironment.

Andrew Viduka working on boring out the barrel of a six pounder gun from HMS Pandora *prior to electrolysis treatment. © Queensland Museum*

Once the exterior of the gun was mechanically deconcreted, the barrel had to be cleaned of concretion, otherwise it would harbour significant quantities of chloride ions that would later promote deterioration.

To release the chloride ions trapped in the graphitized corrosion product layer of the gun, the object was connected to an electrical circuit. The electrical circuit reduced the iron corrosion products to a different electrochemical state, which assisted in the removal of chloride ions by diffusion in alkaline solution.

After deconcretion, the gun was sampled to get a baseline understanding of the chemically bound and free chlorides. This chloride concentration data is used in calculations to provide an approximate time frame for the duration of treatment and the mass of chloride ions to be extracted through an electrolysis/diffusion process.

Once sufficient chloride ions were released, the object was washed to remove all vestiges of the sodium hydroxide solution. After this, the object was taken out from the tub and excess water was chemically removed, before the gun was sprayed with an inhibitor that reacts with chemically available iron ions, to create a stable compound. The gun was then placed into a stable environment to slowly air dry, before being wax consolidated.

The process of wax consolidation involves immersing the gun in a bath of hot microcrystalline wax, which is solid at room temperature. The wax permeates the porous corroded (graphitized) surface of the cannon and consolidates the surface, as well as acting as a barrier to moisture.

2.2.2 Copper alloy

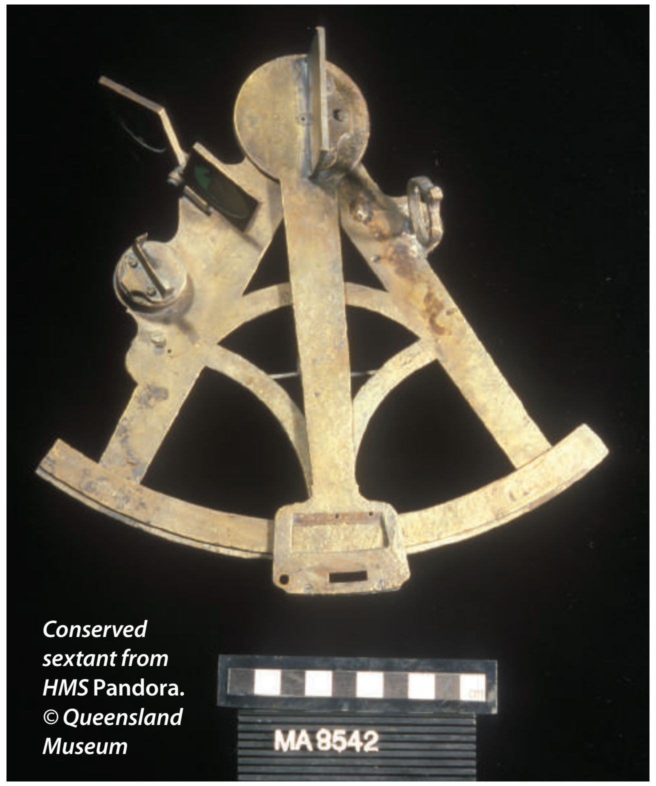
Significant quantities of copper and copper-alloy objects were also recovered from the HMS *Pandora*. Objects made from these materials were used in various applications:

- *Ship parts*
- *Furniture and fittings*
- *Weapons*
- *Tools*
- *Instruments*
- *Domestic equipment*
- *Utensils*
- *Clothing*
- *Accessories*

A sextant was also found during the 1999 expedition. The navigational instrument is a composite object primarily made of brass (a mixture of copper and zinc), with glass optical components. After the concreted sextant was recovered on-site, it was registered, photographed and then wrapped to keep it wet and protect it from any physical damage during its return voyage to the museum.

Initial observations of the concretion of this artefact revealed that there were a number of objects associated in the one concretion. What appeared to be a sextant was heavily concreted, with the 'bulky end' of the concretion appearing to contain both wood and corroded iron. There were three areas on the sextant proper where metal was exposed and each of these areas appeared to be in good condition. There was also a section of a wooden handle exposed.

Before starting to deconcrete the object, it was necessary to take a number of X-rays. The X-rays made it possible to identify separate materials in the concretion, their number, condition and associated location. They also revealed that the sextant was complete. With this information to guide the process, it was possible to successfully deconcrete the artefacts using a small pneumatic pen.

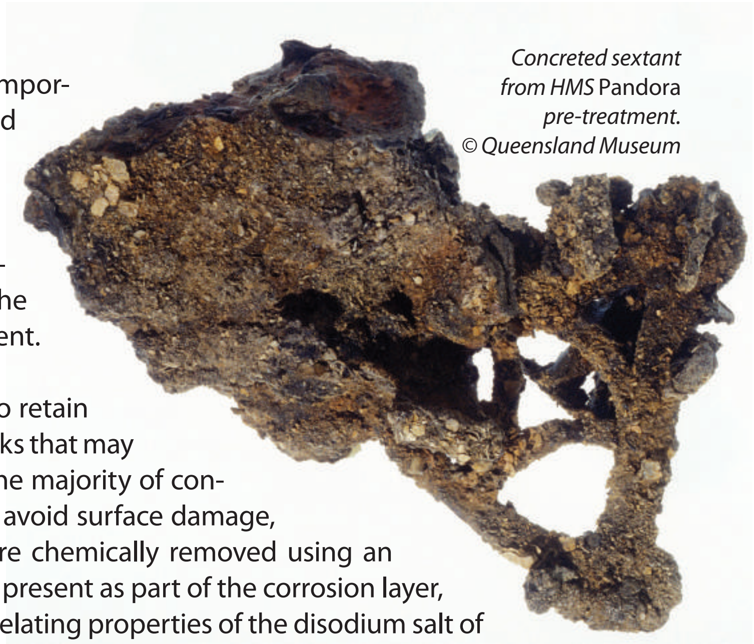


Conserved sextant from HMS Pandora*. © Queensland Museum*

After deconcretion, the brass components of the sextant were placed into a solution containing a corrosion inhibitor for copper, commonly called BTA (benzotriazole). The chloride ion release was monitored until a level was achieved that indicated the process was complete. The brass components of the sextant were then immersed in acetone to dry the metal quickly, removing any vestiges of water that could initiate corrosion. Finally, the object was air dried.

2.2.3 Lead

Lead objects from the HMS *Pandora* include musket shot, touch-hole covers and various types of weights. In comparison with other metals, lead is fairly resistant to corrosion in a marine environment and is usually only covered in a thin layer of concreted matter. Lead is prone, however, to physical dam-



Concreted sextant from HMS Pandora *pre-treatment.*
© Queensland Museum

age due to its softness. For this reason, it is important that lead artefacts be carefully retrieved to avoid further surface impacts. On-site, lead is stored in seawater which is then replaced by normal tap water, sometimes with the addition of other salts, such as sodium sulphate, back at the laboratory. This prevents the material from deteriorating during treatment.

The primary focus for lead conservation is to retain any historic information, such as maker's marks that may be retained in the corroded surface layer. The majority of concretion is usually mechanically removed. To avoid surface damage, any remaining small traces of concretion are chemically removed using an acidic solution. If no historical information is present as part of the corrosion layer, the object can then be stripped using the chelating properties of the disodium salt of EDTA (Ethylenediaminetetraacetic acid). If historically important surface detail is revealed, the corrosion product can be reduced to metallic lead by electrolysis and then consolidated.

An alloy of lead and tin, pewter is harder than lead. Pewter is used to manufacture different types of objects, commonly decorative and household items.

The pewter pot from the HMS *Pandora* featured a 'pustuled' surface, typical of pewter corrosion in a marine environment. This effect occurs as corroding metal tries to force its way through a surface layer of tin oxide. Most of the surface concretion was removed very carefully under a compound microscope, using wooden picks and a scalpel. The pustules are kept intact, as removal only reveals a gaping hole. The pot was then covered with microcrystalline wax, not only as a barrier against moisture, oxygen or pollutants, but also to help consolidate the fragile surface.

Pewter pot from HMS Pandora.
© Queensland Museum

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2.3 Organic Materials

- *Wood*
- *Other plant materials*
- *Leather*
- *Bone, shell, ivory*
- *Horn, tortoise shell, baleen, hair*

The archaeological excavations conducted on HMS *Pandora* have revealed that approximately 30 per cent of the ship's timbers remain. Found within the hull remains were a significant number of small organic objects associated with either the function of the ship or the possessions of the crew.

Examples of the organic objects recovered from the HMS *Pandora* include:

- *Food condiments*
- *Wine*
- *Essences*
- *Spruce beer*
- *Coconuts*
- *Wood*
- *Ethnographic artefacts*
- *Leather*
- *Rope*
- *Cork*
- *Teeth*
- *Ivory*
- *Bone*

Whilst there is no one fixed approach to organic object conservation, the basic stabilization process can be divided into three separate stages:

- *Cleaning and documentation*
- *Consolidation and/or desalination*
- *Drying*

All of these activities are regulated by the need to maintain a dimensionally-stable object. Failure to treat an organic object correctly, results in the loss of its original shape and an unacceptable level of damage caused by internal drying stresses. Damage usually manifests as cracking, warping, checking or collapse of the original surface.

Like most other conservation laboratories conserving wet organic materials (National Museum of Denmark Skudelev ships, *Mary Rose*, *Vasa*, Bremen Cog), the Queensland Museum used a synthetic polymer called Polyethylene Glycol (PEG) and Hoffman's two step method of PEG consolidation (Hoffman, 1985, 1986 and 1996).

Objects treated with this consolidation material are dried either by vacuum freeze-drying (VFD), freeze-drying or controlled air drying depending upon the object's size and significance. VFD reduces or removes internal stresses caused by conventional drying and helps to keep an object's shape and condition. Controlled air drying does not work for wooden objects that have suffered significant degradation. Internal stresses are caused by the most careful of procedures and only an object's inherent condition will save it from deterioration. As a result, controlled air drying should be reserved solely for wet wooden artefacts which are in very good condition and feature only minor surface deterioration.

Another method for consolidation of particularly fragile organic objects and for composite objects is a consolidation treatment called the Cellusolve Method. This method was developed by Inger Bojesen-Koefed, Ion Meyer, Poul Jensen and Kristiane Straetkvern from the National Museum of Denmark. Due to the potentially carcinogenic nature of the chemicals used in this method, only initial trials on corks recovered from the HMS *Pandora* were carried out.

2.3.1 Wood

All of the wood recovered from the HMS *Pandora* required consolidation to avoid loss of the historical shape and surface detail. In the 1999 season, a waterlogged wooden fish hook was recovered. This artefact is one of many ethnographic 'curiosities' from the South-Pacific Islands collected by the crew of the HMS *Pandora*. The fish hook was defined as being waterlogged, meaning that the wood's cellulose structure had been degraded and replaced with bound water. While the water held within the cell walls provided temporary support to the weakened cells, it created a false impression that the hook was in a stable condition. If the fish hook was allowed to dry without consolidation, its cell walls would have collapsed from internal stresses, causing irreversible damage, such as dimensional shrinkage, cracking, checking and delamination.

Following documentation, treatment began with basic surface cleaning. The hook was gently washed and brushed under running deionised water. After wet cleaning, the hook was placed into a solution of synthetic wax called Polyethylene Glycol (PEG) which replaces bound water by osmotic diffusion. This was a long process in which various grades of PEG (a grade is determined by the length of the polymer chain) were progressively added in increasing concentration, to avoid osmotic shock and possible cell collapse. By filling the lumens and cell cavities of the wood with PEG, the hook was given greater structural support.

Following consolidation, the hook was frozen and then vacuum freeze-dried, a procedure that involves the conversion of water from its frozen state into a gaseous phase. This type of procedure is used to avoid drying stresses that would cause damage to the deteriorated object. Once dry, excess PEG that had solidified on the surface was mechanically cleaned. Fragments of the object were joined and rope strands were consolidated using a chemically stable and reversible adhesive. Finally, the object was packed so it could be viewed for study without necessarily handling it.

The desalination wash treatment of an organic object is an identical process to that performed for glass and ceramic objects.

Fish Hook from HMS Pandora *after treatment.*
© Queensland Museum

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2.4 Composites

One of the largest finds of the 1999 season was an earthenware ceramic olive oil jar. This was the fourth 'Ali Baba jar' recovered from the HMS *Pandora*.

Large rough earthenware jar from HMS Pandora.
© Queensland Museum

This earthenware jar, however, was quite different from its three predecessors. After the olive oil had been consumed, this jar had been reused as storage for a number of objects: tacks, roves, nails, rivets and hammer heads.

An artefact with parts made from a number of material types is termed a 'composite object'. In this case the object was made up of ceramic, leather, fibre, wood, iron, copper and stone. Until excavation in the laboratory could separate the individual artefacts, the contents of the jar had to be stabilized as a composite object.

The conservation treatment to stabilize a composite object is generally a compromise between what would be ideal for each material type individually, and what is ideal for the whole. Upon arrival at the museum, the first step in the conservation process for the Ali Baba jar was to place the entire object into a solution with a near-neutral pH, in conjunction with a number of corrosion inhibitors.

The objects located inside the jar had not been exposed to any physical damage during their 200 year burial and had a reduced corrosion or biological deterioration rate, because of the lack of oxygen in the burial environment. Chemical deterioration of the internal iron and leather objects was primarily caused by sulphate-reducing bacteria. This type of deterioration, for example, is significantly slower than corrosion of iron in an oxygenated environment. As such, the inorganic artefacts inside the jar were in good condition and the organic artefacts were still preserved.

Due to the density of the object, no X-ray images of the jar's contents or their arrangement was possible. Since the first priority in the treatment of a composite object was to separate the object into parts and treat each material individually when possible, excavation of the jar was immediately required to simplify the conservation process and extract the maximum archaeological information from the artefact.

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3 Finds Handling 'First Aid'

3.1 General Artefact Processing

Conservators are responsible for recovered artefacts on site at all times. A conservator's job on an excavation is to minimize the shock experienced by an object as it moves from a stable environment where it has come into some form of equilibrium, to one where it is exposed to rapid deterioration potential by excavation. If it is wet, keep it wet. If it has come from the sea, put it into sea water; if from a fresh water lake, put it into lake water. Ianna and Richards (1996) give a very good summary of the roles and responsibilities of the on-site conservator and much of the information in this section is drawn from that document.

Lifting objects is often a collaborative affair. Dependant on the environment where the object is being recovered from, the lifting techniques can vary significantly. It is sufficient to encourage people to work from first principles and remember that the aim is to mitigate shock, vibration and movement, as the object moves to the surface. It is best if objects are placed into containers that are 'snug fits', i.e. if the container is slightly too big for the object, it is advisable to put some sand in with it.

General assumptions are often made about material types recovered from the excavation to promote effective processing in the lab. Objects deemed fragile could include glass, ceramics, bone, ivory, rope, leather, textile, parchment, pewter, silver, gold and any extensively corroded small objects. Wood can be fragile (a classic example of much deteriorated wood is timber from the bog site of Nydum Mose, Denmark), however, all wooden surfaces are usually fragile. Sound objects are generally inorganic objects, larger metal objects, stone, shell and concreted masses. Wood can be sound, but the surface can also be marked easily and should be treated as fragile.

Divers recovering large earthenware jar from HMS Pandora in 1999. © Queensland Museum

Artefacts should only be handled and packed once. Those artefacts that are in pieces should be kept together in one bag. Packing for transport back to the laboratory should be carried out straight away and it is imperative that objects (even if in crates) are not left out in direct sunlight. Objects should only be handled by the designated person, i.e. during their removal from crate or container, into storage or a solution. This gives clear lines of responsibility and removes the potential for mistakes.

Sea water is acceptable as the storage medium (always for lead). There are a number of storage solutions for particular material types. The basic aim of all these storage solutions is to help stabilize the object. For example, an iron object is placed into a solution that passivates the metal by increasing the alkalinity of the sea water from approximately pH8 to a pH11+.

Artefacts, especially organic materials, should be kept moist with a spray bottle of water during photography, sketching, publicity and assessment for analysis potential. Fragile artefacts should be photographed quickly and packed for transport.

If possible, the majority of marine organisms from objects should be removed, this reduces excess weight and enables for more objects to be collected with limited supplies.

Light and heavy artefacts should be stored separately. It is important to differentiate between material types and store accordingly, as some objects actively promote deterioration of others. If in doubt of an object's material type, it is best to store it separately. Metals should not be stored with organics, except in the case of composites.

Objects impregnated with metal corrosion products (wood) should not be stored with objects not impregnated. Look for staining (generally a reddish iron oxidation colour or green for copper) on the object's surface as an indicator of contamination with corrosion products. If unsure, treat as impregnated. Biocides should be used in the storage solutions of organic materials (0.05 per cent Panacide is an example of a biocide and the low concentration needed to control fungal activity). This is particularly the case in the tropics.

Label both the artefact and the storage container, and then label the contents of all storage solutions on the containers.

Larger timbers can be stored in tanks or holes in the ground lined with plastic. If this is not possible then wrap them in Hessian that has been soaked in sea water and a biocide, and seal the object in a plastic bag. Additional water should be added prior to sealing.

Leskard (1987) and Kimpton (1985) focus on lifting, supporting and packing for transport large deteriorated timbers. Other good examples of lifting timbers can be found from the excavation of the Skudelev ships and La Salle's *La Belle* by Texas A&M.

Conservator working on the back deck during the HMS Pandora *expedition. © Queensland Museum*

Do not pack heavy artefacts with light artefacts. All artefacts require wrapping to help retain a high humidity around the object during transit (usually a combination of paper cloth/towel with bubble wrap on the outside). Do not use tissue, cotton or wool that is likely to leave fibres. Exfoliating glass or ceramics can be wrapped in fine gauze (Stabilex) to keep the surface intact or to contain disbonded surface pieces.

To achieve minimum movement in storage container, wrap the artefact in wetted cloth and place in a sealed plastic bag as soon as possible. Do not add additional water to bag prior to sealing. Small objects can then be further put into small sealable boxes and finally into larger plastic bins (50 litre sized bins).

Jon Carpenter (1987) from the Western Australia Museum very successfully used Agrosoak as another medium in which to transport objects from the field. Agrosoak not only helped keep objects, but also offered support to small glass and ceramic objects. This is particularly useful when working from a dive platform as sea conditions can be variable.

Onsite conservation HMS Pandora*, 1999. © Queensland Museum*

Some finds, such as Mercury, are dangerous to your health. When handling finds on site, particularly if the archaeology/history suggests that such finds are likely, use gloves at all times. If the object is a liquid, keep the bottle or container upright, pad to avoid breakages and keep the object fully immersed. All material that has come into contact goes into the container. Containers should be sealed with tape and labelled very clearly, before being placed into cold storage.

If bone or ivory finds are recovered and there is capacity on site, pack objects and place into a cold environment (cooler chest with freezer blocks) or a fridge. A target steady temperature of 10 °C is suitable.

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4 Casting

In archaeological conservation, the main purpose of casting is to obtain a three-dimensional record of an object or arrangement of objects that could be lost through excavation, deconcretion or treatment. Casting is also used to provide replicas for display or education purposes. Casting is a very useful tool for revealing information hidden within concretions. The on-site conservator needs to be able to cast so that valuable information is not lost.

Over a period of time on the seabed, calcareous matter can grow over an object, often obscuring it and creating what is known as a concretion. Iron objects covered by concretions continue to corrode, and the corrosion products move into the surrounding concretion. If there is sufficient time and the environmental conditions are conducive to promoting corrosion, an iron object can corrode away completely, sometimes leaving a nearly perfect negative of the original form. This negative space is called a pseudomorph.

For concretions in which pseudomorphs have formed, casting is the only way the shape can be revealed in the positive. It is important that the casting is done well as it is often the case that the concretion has not been sectioned prior to casting, so it will need to be destroyed in order to remove the cast form. Typically, wrought iron objects, rather than cast iron objects, corrode away entirely within a concretion, producing a pseudomorph suitable for casting. Taking an initial X-ray of the concretion can help to ascertain how much of the original metal still remains and whether casting may be the best option. Often X-raying concretions does not reveal a lot of information as the strength of the X-ray is too limited for the industrial application at hand. Fine detail, such as makers' marks, broad arrows and other engravings, can often be revealed from casting.

There are a variety of materials and methods that can be used to cast concretions. At the Queensland Museum, a two part silicone-based product (base and catalyst) was used, which provides good working and setting properties, and is chemically stable long term. The flexible silicone cast can be recast with hard epoxy resins if required. When recast with an epoxy resin, appropriate colours can be added to resemble the original object.

The silicone casting mixture is poured into the top of a concretion, which has had all other exit holes blocked. The silicone cast, which cures in 24 hours, is removed by simply pulling it free of the concretion. For more complex forms, the concretion needs to be broken to free the cast.

It is also possible to cast a concretion in two parts and then join them together afterwards to produce the entire form. This is a helpful technique when the form is complex. The advantage of this method is that the concretion can be retained for further casts or used for display purposes.

Cast of a wrought iron object from a pseudomorth found on the HMS Pandora. *© Queensland Museum*

Unit Summary

Conservation can be defined as all measures and actions aimed at safeguarding tangible cultural heritage, while ensuring its accessibility to present and future generations. Conservation embraces preventive conservation, remedial conservation and restoration. All measures and actions should respect the significance and the physical properties of the cultural heritage item.

Conservation is a specialization with its own ethical parameters. It is important to understand the concept of conservation ethics and the difference between conservation and restoration, with reference to the ICOMOS – CC definitions.

On-site conservation requires planning and coordination to be carried out effectively. There is a need for conservators and archaeologists to follow excavation planning processes regarding the types of objects to be recovered and the sampling methodologies to be employed on-site and above water. The need for sampling procedures and methodologies has to be established pre-excavation to ensure the maximization information is recovered. Following this, the above water first aid treatments for a range of organic and inorganic objects that are typically recovered from shipwreck sites can also be outlined.

Careful consideration must be given to an artefact's potential for preservation *in situ* and any conservation issues that may arise once recovered and stored in particular environments.

The conservation of objects is predicated on their chemical and physical stabilization, however, archaeological material does not always warrant treatment and in some cases no conservation or the most minimal conservation treatment is awarded. Prioritizing treatments allows us manage and reduce costs in the post-excavation process and can potentially allow research findings to be published more quickly. To achieve this, treatment planning must take into consideration the utility of the archaeological object for chemical analysis, typological, historical research or display, within the framework of answering archaeological questions.

Suggested Timetable

15 mins	Introduction to Finds Handling and Conservation
75 mins	Materials, their Deterioration and Conservation
	Break
90 mins	First Aid for Finds
	Break and Transfer to Next Site
90 mins	Site Visit 1 *In Situ* Archaeological Site or Conservation Laboratory
	Break and Transfer to Next Site
90 mins	Site Visit 2 Museum - Group Activity and Discussion
20 mins	Concluding Remarks and Closure

Teaching Suggestions

This unit introduces students to conservation and finds handling techniques. Trainers should present the information in a series of lectures, followed by field visits and practical group activities as outlined in the suggested timetable.

Discussions can be useful way for students to share knowledge and perspectives, further enhancing their understanding of the material. Language and culture issues need to be considered by trainers so that as many students as possible are included in the discussion.

Since the vast majority of students will be underwater cultural heritage managers or maritime archaeologists, it is important that the trainers do not attempt to turn them into conservators, but instead should focus on communicating with the audience in an engaging way. The best way to do this is to explain what conservation does for archaeology; essentially the capture and preservation of information that can then be interpreted. It is also useful to highlight where this specialization may contribute to planning fieldwork and what responsibilities a conservator will undertake in the field as well as in a museum context.

Please note that there exists a cultural difference in the concept of conservation and restoration, and these differences are often embodied in the training given to conservators from different countries. Trainers will need to be sensitive to these differences and be able to modify their lectures accordingly.

Practical Sessions

Site Visit 1

Students should visit an archaeological site or conservation laboratory where they can see a range of archaeological material types in different conditions. Ideally these materials should not be conserved or going through conservation. The aim of this site visit is to get students out of the class room environment so that they can apply and re-iterate information given to them in the lectures. If a conservation laboratory is available and specific treatments are currently underway, trainers should take the opportunity to discuss with students the object, the treatment methodology being used and the rationale behind these choices.

Site Visit 2

During the second site visit, students should be divided into small groups. Each group should be asked to walk around the displays and using the knowledge provided in the series of lectures, assess the condition of objects, the display cases and their location within the building space and the museum environment. ,

The aim of this exercise is to get students to look at objects and apply some of the conservation principles that have been discussed throughout the unit. Trainers should also encourage students to also look at objects as a responsible archaeologist and propose a methodology that could be used to recover certain materials from a given site. It is important that students take into account issues related to location, depth, available bottom time, current, sea conditions and weather.

Students should also look for fragile or large organic and inorganic objects, and consider their conservation needs from the site to the Museum. Students should be able to demonstrate an understanding of the logistics and approximate costs required for recovering items of that nature. Remember to highlight an archaeologist's ethical responsibilities, at all times.

Conservation Preparation Planning Exercise

This additional exercise can be given to students as an overnight activity.

Trainers should provide students with a scenario that outlines a particular site, ideally related to the site selected for the practical diving project. The scenario should describe the nature of the site, the likely material culture to be found, environmental conditions, depth, current, accessibility and visibility.

Students should form small groups and be given the task of preparing a conservation plan for that site.

The plan should include the following sections:

- *Site*
- *Expertise/personnel*
- *Planning/Managing*
- *Project processes*
- *Infrastructure*
- *Equipment*
- *Materials*
- *Workspaces/tasks*
- *Long term issues arising from recovered materials*

Due to the diverse nature of training groups and the fact that English is not necessarily the first, second or third language for some students, use assessment through group participation where possible.

Additional Individual Exercise

Using your knowledge of site formation, think about what types of materials you have seen in high energy sites (waves breaking on shore) and in low energy sites (like deep lakes). Is there a difference? Why? Look at the key factors above and think about it from the perspective of those parameters and their inter-relation.

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Useful Websites

- *Australian Institute for Conservation of Cultural Materials:* ***www.aiccm.org.au/index.php?option=com_content&view=article&id=6&Itemid=4*** *(Accessed February 2012.)*
- *Bibliographic Database of the Conservation Information Network (BCIN):* ***www.bcin.ca/English/home_english.html*** *(Accessed February 2012.)*
- *Code of ethics for conservators :* ***icom.museum/fileadmin/user_upload/pdf/Codes/code2006_eng.pdf*** *(Accessed February 2012.)*
- *English Heritage Phase3 Assessment of Potential for Analysis:* ***www.eng-h.gov.uk/guidance/map2/map2-6.htm#sect6*** *(Accessed February 2012.)*
- *English Heritage Project management using MoRPHE:* ***www.english-heritage.org.uk/professional/training-and-skills/training-schemes/short-courses/project-management-using-morphe*** *(Accessed February 2012.)*
- *ICOM Conservation:* ***www.icom-cc.org/*** *(Accessed February 2012.)*
- *Metals Working Group:* ***www.icom-cc.org/31/working-groups/metals*** *(Accessed February 2012.)*
- *Wet Organic Archaeological Material Working Group:* ***www.icom-cc.org/42/Wet%20Organic%20Archaelogical%20Materials*** *(Accessed February 2012.)*