Exploring Practitioners’ Attitudes Towards *In Situ* Preservation and Storage for Underwater Cultural Heritage

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Declaration

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief, it does not contain any material previously published or written by another person except where due reference is made in the text.

Nicole Ortmann 13th January 2009
Abstract

This thesis explores existing attitudes towards the practice of in situ methods of preservation and storage held by practitioners worldwide. With the UNESCO Convention on the Protection of the Underwater Cultural Heritage now in effect in its twenty-two signatory countries, the practice of in situ preservation and storage stands to become a significant part of managing submerged cultural heritage. It is important that a clear understanding of the practice be provided to practitioners in order for these cultural resources to be best protected. A literature review of archaeological and scientific projects and experiments was undertaken to provide a basis from which currently held attitudes could be investigated. A questionnaire was developed that assessed how practitioners utilise and understand in situ preservation and storage as well as what types of methods are being used and the reasoning behind practitioners’ choice of methods. The online questionnaire, aimed at a multi-disciplinary group of practitioners, produced a wide range of responses that highlighted the complex uses and understandings that exist about in situ methods. Key issues included a lack of a cohesive definition of in situ preservation and storage that clearly designates what constitutes in situ methods as opposed to neglect; the difficulties faced by practitioners in terms of financial, political and legislative concerns; the perception that in situ methods curb the traditional collection of data through excavation; the continued need to preserve sites based on site-specific parameters; and the impact of in situ preservation and storage on public and academic access. The resulting thesis is a significant resource in terms of understanding current practices, directing future research and continuing the discussion of how practitioners approach the management of underwater cultural heritage.
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Chapter 1: Definitions and Methods

Introduction

‘[H]istory is, in large part, a catalogue of examples of in situ [sic] preservation’ (Holden et al. 2006, p. 59)

As the quote above attests, in situ preservation occurs naturally, to an extent, within archaeology as a whole. This preservation can sometimes be even more pronounced in waterlogged and submerged environments. From the discovery of Swiss Lake Villages in the 1850s (Delgado 1997, p. 233-235; Desor 1865) and Roman shipwrecks in the early twentieth century (Delgado 1997, p. 233; Muckelroy 1998, pp. 29-31; Ucelli 1950) to the modern and high-tech explorations of the deep ocean that have revealed ancient wrecks such as the Skerki vessels (McCann 2001, p. 257; McCann & Oleson 2004), archaeologists have been aware of the innate natural ability of water, and especially waterlogged sediments, to preserve a wide range of cultural materials. In the last few years, trends in submerged cultural heritage management have been towards in situ preservation and storage for a number of reasons, such as financial and curatorial considerations (Corfield 1996, p. 33; Oxley 1998b, p. 159; Stewart, Murdock & Waddell 1995, p. 793). But while archaeological sites in submerged and wetland areas continue to be discovered, proving that natural preservation is possible, the chemical, biological and physical mechanisms behind these discoveries have only recently begun to be explored (Caple, Dungworth & Cogg 1997, p. 57; Corfield 1996, p. 32; Manders 2004b, p. 279; Oxley 1998b, p. 159).

Textbooks focusing on underwater archaeology or heritage management often include sections about in situ preservation (Babits & Van Tilburg 1998, p. 590; Dean & The Nautical Archaeology Society 1992, p. 332; Green 2003, p. 470). A review of these texts seems to demonstrate the concept lacks cohesive definition. This can lead to an understanding by newcomers to the archaeological field that wet sites reach equilibrium with their environment and therefore, if not physically disturbed, will remain stable over time. While to an extent this is true and may be preferable to any type of disturbance, the “don’t touch” attitude does not necessarily constitute in situ preservation. The site will change as the environment
around it changes and actions must be taken, either through active intervention or monitoring, to confirm that these changes are not affecting preservation.

Over the last decade or so, *in situ* forms of preservation and storage have been consistently emphasised as the preferred option under most circumstances for preserving submerged and waterlogged cultural heritage for future generations (Babits & Van Tilburg 1998, p. 590; Bergstrand & Nyström Godfrey 2007, pp. 7 & 15; Dean & The Nautical Archaeology Society 1992, p. 332; Green 2003, p. 470; International Council on Monuments and Sites 1996, p. 1-5; United Nations Educational, Scientific and Cultural Organization 2001, p. 56-61). The United Nations Educational, Scientific and Cultural Organization (UNESCO) underscores the use of *in situ* methods in its 2001 Convention on the Protection of the Underwater Cultural Heritage (United Nations Educational, Scientific and Cultural Organization 2001, pp. 51 & 58-60) as does the 1996 Charter for the Protection and Management of the Underwater Cultural Heritage adopted by the International Council on Monuments and Sites (International Council on Monuments and Sites 1996, p. 2). Many other organisations, while not formally installing *in situ* preservation into their by-laws or constitutions, still stress the importance of this concept in their educational programmes; the Nautical Archaeology Society (NAS) in the United Kingdom is one such group. If *in situ* methods are to be promoted as the primary means of preserving underwater cultural heritage, they must be explored in depth, or it could be difficult to argue that *in situ* preservation and storage methods are truly in the best interest of the artefacts, features and sites.

During the last ten years, studies have been undertaken to explore the idea of *in situ* preservation and storage in order to test the assumptions made about the preservative nature of sediment coverage in waterlogged environments, either natural or through reburial. Programmes such as Reburial and Analyses of Archaeological Remains (RAAR) in Marstrand, Sweden (Bergstrand & Nyström Godfrey 2007) and Monitoring, Safeguarding and Visualizing North-European Shipwreck Sites (MoSS), involving a number of European nations such as Finland, Denmark, the Netherlands, Germany, Sweden and the United Kingdom (Cederlund 2004), have been carried out in the field on a number of sites. Laboratory studies by Björdal, Nilsson and others in Sweden have also shown that
there is merit in pursuing *in situ* methods (Björdal, Daniel & Nilsson 2000; Björdal & Nilsson 2008; Björdal & Nilsson 2002; Björdal & Nilsson 1999; Björdal, Nilsson & Daniel 1999; Björdal, Nilsson & Petterson 2007). In Australia, work on several wrecks has been particularly important in experimenting with the use of sacrificial anodes on metals and reburial schemes (Godfrey et al. 2005; Hosty 1988; MacLeod 1998a&b; MacLeod 1993; McCarthy 1987; Moran 1997b; Nash 1991; Winton & Richards 2005).

It is not just the methodology that needs to be addressed. Central to implementing *in situ* preservation and storage is an understanding of current attitudes towards, and uses of, *in situ* preservation methods among practitioners in light of recent research. Who is using *in situ* preservation methods and why? If practitioners are, as a whole or in part, not using *in situ* preservation and storage, what are the reasons? What forms are the most prevalent and why? Through understanding the current research and methods of *in situ* preservation and storage, patterns may emerge that will inform changes to research and highlight trends crucial to understanding the future of the practice.

**Defining *In Situ* Preservation and Storage**

In order to explore this topic in more depth, it is necessary to create definitions that will allow the subject matter to be limited to a manageable size. Waterlogged sediment occurs in a variety of different areas, including urban and rural terrestrial sites. In the United Kingdom, for example, English Heritage has funded substantial work on wetland sites dating from the Neolithic through the Medieval period (Caple 1998; Caple, Dungworth & Clogg 1997; Corfield 1996; Goodburn-Brown & Hughes 1996). As the intent of this thesis is to explore underwater and maritime heritage, sites such as these will not be addressed in this study. To this end, the following three definitions will be applied to determine the types of sites to be explored. These definitions will apply throughout the research conducted here.
Maritime Archaeology

The archaeological study of human interaction with the sea through seafaring. This includes not only the vessels themselves, but port and harbour structures; fishing, whaling and other maritime subsistence activities; lighthouse and shore-based structures that aid in seafaring; and any other type of site that has connections to the use of the sea and its resources by humans.

Underwater Site

Any site, feature or artefact found in a body of water, whether it be a lake, river or sea; these sites may include those which have become inundated over time and are currently underwater, such as habitation or ceremonial sites.

Waterlogged Terrestrial Site

Any site that may now be treated as a terrestrial site, but was at some previous time under any body of water such as a lake, river or sea and which people interacted with as a water body for the purposes of transport, subsistence, economy or ceremony. These sites will not include sites which have always been terrestrial but yet waterlogged unless they can be clearly related to the maritime landscape through the above definition of maritime archaeology.

In Chapter Three, examination of the experimental literature will include work completed in waterlogged terrestrial sediments, as the nature of the work and its conclusions will be valid, especially in the case of waterlogged terrestrial sites as defined above.

It is also useful to define in situ preservation and storage. Submerged and buried maritime heritage exists in an environment that, without disturbance, is conducive to long-term preservation of a variety of archaeological materials (Bergstrand & Nyström Godfrey 2007, p. 10; Corfield 1996, p. 32). Once these sites are disturbed, chemical, biological, and physical forces begin to destroy the fragile stability. In situ preservation and storage aims at restoring this stability by slowing down the mechanisms of deterioration and degradation (Corfield 1996, p. 32). It is important to note that these techniques do not stop deterioration of archaeological materials. There are many ways to provide stability and often the delineation between them is blurred. The following definitions are aimed at providing some clarity.
**In situ preservation**

Any steps taken on or intervention with a site in order to extend its longevity while maintaining original context and spatial position; while artefacts and features may have been excavated and/or removed, the site itself remains in place and retains all or a majority of its original context.

**In situ storage**

Any steps taken to preserve the physical, historical and aesthetic integrity of artefacts and features excavated from a site through the creation of a separate space where items are stored within the confines of an environment similar or deemed to be more beneficial to that from which they were removed.

In situ preservation is based on the concept that certain environments naturally produce situations capable of slowing deterioration. As Holden et al. (2006, p. 59) indicate, it is this very process that allows archaeologists to uncover the past through excavation. Early reburial schemes, such as those used at Red Bay, were in part based on that idea (Stewart, Murdock & Waddell 1995, p. 794). The inclusion of conservation scientists with various chemical and biological backgrounds led in some instances to the adoption of well-established scientific principles into conservation strategies. The use of sacrificial anodes and cathodic protection for iron artefacts by MacLeod on the Sirius site (MacLeod 1996a, p. 111), while promising in terms of in situ developments, was originally intended to provide increased stability in conjunction with conventional forms of retrieval and treatment. Since then, anodes have been used to protect sites in situ where there has been no intention of retrieving remaining materials (Heldtberg, MacLeod & Richards 2005, p. 75; MacLeod 1998b, p. 81; MacLeod 1995, p. 53; MacLeod et al. 2005, p. 53).

As more emphasis is placed on protecting submerged cultural heritage, it becomes crucial to understand how in situ preservation and storage is perceived and utilised to protect these resources. With UNESCO having taken effect on 2 January 2009 and impacting 22 signatory states, the prevalence of in situ programmes stands to increase and the methods used could impact protection of submerged cultural heritage either positively or negatively. What is known about in situ preservation and storage? What projects currently use these methods and how successful are they? What contributions are being made by other disciplines and how are they
incorporated into the fields of archaeology and cultural resource management? And by what mechanisms can these questions be addressed?

**Methodology**

In order to investigate current practitioners’ attitudes towards *in situ* preservation and storage in a cohesive manner, a suitable approach was needed. To determine what types of influences would be acting on practitioners, it was essential to understand the body of literature produced. A mixed-methods research design was developed that allowed for the literature to inform a mainly quantitative approach to collecting information about attitudes through a questionnaire. Central to this decision was the issue of interdependence: the question of practitioners’ attitudes was dependent on a qualitative reading of the literature (Creswell & Plano Clark 2007, p. 34). Triangulation Design was chosen, specifically a convergence model that allowed the qualitative and quantitative to be collected and analysed separately and the results of each to be combined to produce an interpretation (Creswell & Plano Clark 2007, pp. 64-65). The intent of this model was to provide a legitimate set of conclusions demonstrating how *in situ* preservation and storage is understood and used. The two methods used in this model have been a literature review and a questionnaire.

**The Literature Review**

A literature review is a ‘systematic, explicit, and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners’ (Fink 2005, p. 3). Literature reviews describe a current body of research with the objective of explaining and guiding professional practices, by identifying and developing new avenues of research or through interpreting existing literature (Fink 2005, pp. 8-10). In this thesis, the literature review was approached from a qualitative standpoint as the intent of the review was inductive and exploratory.

**The Questionnaire**

A questionnaire was developed to evaluate attitudes towards *in situ* preservation and storage by practitioners throughout the world. A number of texts were consulted (Alreck & Settle 2004; De Vaus 2002; Foddy 1988; Foddy 1993). The
sampling method chosen to define participants followed the method of non-probability purposive sampling (De Vaus 2002, p. 91). This is based on the notion that the questions to be asked require a certain amount of insider knowledge in the field of maritime and underwater archaeology, as well as conventional and *in situ* methods of preservation. A list of those invited to participate was drawn in part from the review of the literature. This provided a solid basis from which to expand as it was composed of current practitioners in the scientific, archaeological and heritage conservation and management communities. In addition to this, discussion with individuals in these communities known to the researcher identified other participants through professional relationships. The Nautical Archaeology Society in the United Kingdom agreed to circulate a request for participation to the membership and the online Museum of Underwater Archaeology (MUA) managed out of Rhode Island was amenable to posting a notice on its website. Other groups approached included members of The Conservation Digest and Sub-Arch list serves, as well as the Society for Historical Archaeology (SHA), the Australasian Institute for Maritime Archaeology (AIMA) and the American Institute for Conservation (AIC). Through this method of networking, a representative sample of practitioners covering most professions, such as research scientists, archaeologists, conservators and academics in related fields was created.

**Aims and Objectives**

The first section of this thesis uses a literature review to explore current practices in *in situ* preservation and storage. *In situ* methods have been developed through interdisciplinary research and this dichotomy is apparent in the literature. A clear delineation between research that has focused on archaeology and those emphasising chemistry and biology seems to exist. Therefore it was decided that the literature would be reviewed in two chapters, one concentrating on projects in which *in situ* methods have been put into practice on archaeological sites and one focusing on projects aimed at exploring chemical, biological and physical processes.

The second section explores existing attitudes within the professional communities through the use of a questionnaire. The questionnaire was developed
with the intent to quantitatively and qualitatively measure how in situ preservation and storage have been or are being utilised by archaeologists, conservators and research scientists. An examination of the questionnaire and the software used to disseminate, collect and examine it and the results is presented. A discussion of the statistical methods used to evaluate the data accompanies the presentation of the analysed results. Both the questionnaire and the collected data appear as appendices.

The final section explores the implications of the questionnaire and literature review by combining and analysing the results in order to underline current trends and patterns. Identification of possible future work based on analysis of the questionnaire and literature review is addressed. Evaluation of the methods used to gather subject matter will have the advantage of highlighting the validity of the results and could also advance new hypotheses for further exploration.
Chapter 2: In Situ Preservation and Archaeology

Reviewing the Literature

In order to understand what is currently in use, a literature review was performed. Understanding what developments and ideologies may have had a hand in informing possible attitudes also proved helpful for designing the questionnaire employed to collect and assess practitioners’ understandings of the subject (Creswell 2003, pp. 88-89). The following provides a description of the methodology used to locate and review the literature explored in this and the succeeding chapter.

By applying the developed definitions of maritime, underwater and waterlogged sites, a number of databases, such as ScienceDirect, Wiley Interscience and Web of Knowledge, were explored in order to identify possible items for review. Content deemed useful was read and summarised; of particular importance were the bibliographies as these were able to generate items of interest that had not been found during initial research. These were then divided into two separate groups: those approaching in situ preservation and storage from a primarily archaeological stance, and those approaching the subject in terms of the chemico-physical and biological. The former category consists mainly of archaeological surveys and excavations carried out by archaeologists based on a variety of understandings about in situ methods and techniques. Some projects may have had conservators present who informed the preservation process while others did not. The main delineator is that the intent of the project was to preserve remains in situ, regardless of what form was used. In the second category, the projects were experimental in nature, with the intent being to understand the processes behind in situ preservation. These studies were less focused on preserving particular underwater cultural heritage and more on understanding or developing methods and techniques.

Using an exploratory approach (Hart 1998, p. 47), a broad understanding of both types of literature was developed that defined the history of the topic as well as the current state. Questions asked were based on those defined by Fink (2005, p. 53). Was the research design valid and were the sources on which it was based consistent and applicable? Were the methods used appropriate and are the results
yielded significant and practical? Was there an understanding of the strengths and weaknesses of the research?

Also of importance was assessing whether or not the current body of literature was accessible to the widely varied audience using it to inform subsequent projects and research. Here, the explanatory approach was used to explore the event, in this case, current practitioners’ attitudes. What types of attitudes were prevalent within the literature and could these views be linked to the current state of research? This, along with a summative evaluation of the literature, provided a basic overview of existing research and projects. From this knowledge base, abstract ideas about in situ preservation and storage were reformed into questions that fashioned the questionnaire.

Certain limitations became evident during research. The amount of literature to be reviewed meant that studies deemed by the researcher to be more inclusive or significant received more attention. This introduced a particular bias into the research. The interdisciplinary nature of the literature also proved restrictive. This in itself highlighted the varied nature of the subject, which will no doubt continue to be an area for development. The language barrier also limited the extent of the review. Only literature available in either English or French was explored.

Exploring the Archaeology

Over the years, a number of different archaeological projects have applied various in situ preservation methods. A number of reasons have necessitated these projects, such as economic feasibility (Stewart, Murdock & Waddell 1995, p. 791) and responses to site instability issues (Hosty 1988, p. 13; Staniforth 2006, p. 52). Some have been more carefully monitored for longevity and impact than others (Bergstrand & Nyström Godfrey 2007, p. 15). The main research objective of these in situ applications was and continues to be the preservation of archaeological remains. This sets them apart from other investigations such as BACPOLES, MoSS and RAAR (see Chapter Three), which focus on the scientific processes behind in situ preservation and storage. A number of these archaeological projects have included sampling and monitoring programmes (Guthrie et al. 1994; Pournou, Jones & Moss 1999; Stewart, Murdock & Waddell 1995) which provided chemical, biological and environmental information to
enrich and expand this relatively new field. These projects, however, have continued to be aimed at protecting cultural remains and do not emphasise experimentation leading to an understanding of the science of *in situ* preservation. These projects have met with varying degrees of success. While by no means exhaustive, the following explores a number of projects that have reported the results of applied *in situ* techniques.

**Reburial and Re-covering Methods**

A number of techniques have been developed in the reburial or re-covering method of protection. The idea of using a physical barrier to protect sites is based on the notion that the original burial site created conditions conducive to preserving archaeological materials. Recreating or imitating the original conditions should, in theory, provide similar protection (Oxley 1998a, p. 91). The goal in the majority of these projects is to re-create a stable reburial environment, slowing chemical, biological and physical deterioration. This can be accomplished in different ways, such as backfilling of excavated sediment, installing various forms of barriers and encouraging sediment deposition on site (Oxley 1998a, pp. 97-100 & 104; Oxley 1998b, p. 159). Barriers can include sandbags and geotextiles while sediment deposition can be encouraged with mats of artificial sea grass, debris netting or geotextiles (Oxley 1998a, pp. 100-104; Oxley 1998b, pp. 159 & 165). Each of these techniques has its own inherent advantages and disadvantages.

In terms of archaeological use of *in situ* preservation, reburial seems to be the first method to be used regularly. An attempt to stabilise the barque *Day Dawn* in 1982 utilised a sediment drop in order to bury the vessel (Moran 1997b, p. 129). This unfortunately failed as did a later attempt to protect *William Salthouse* by the same technique (Harvey 1996, p. 3; Hosty 1988, p. 13). This was in part due to the type of sediment used in the drop; finer sediment such as sand is often carried away by currents before it has a chance to settle on site (Oxley 1998b, p. 168). Heavier sediments, such as gravel or even reuse of ship ballast, are more successful, though questions remain about whether or not this can damage the site (Oxley 1998b, p. 168). While this form of reburial may be cost effective, Oxley (1998b, p. 168) notes that planning in terms of site environment, type of sediment
used and how the drop is to be completed is a key element in ensuring the success of this technique.

Backfilling of archaeological sites remains standard practice. While some may not consider it *in situ* preservation, it does provide stability. It is also cost efficient and requires little else in terms of materials. Sites such as *Pandora*, in Queensland (Gesner 1993, p. 7; Guthrie et al. 1994, p. 19), and the Legare Anchorage wreck in the Biscayne National Park, Florida (Skowronek et al. 1987, pp. 316-317), have used this method in an effort to safeguard the sites from unscrupulous divers and protect exposed timbers from aerobic biological deterioration.

Parks Canada undertook an extensive reburial project in the 1980s on a whaling site at Red Bay, Labrador. When confronted with a large site that included a number of galleons as well as several other small vessels, they were forced to consider alternative means to preserve the various components of the site. Among the factors that are said to have influenced the use of reburial were character of the resource, the impact of intervention on the physical and historic integrity of the site and the availability of funds and personnel (Stewart, Murdock & Waddell 1995, p. 794). While it is possible that these factors were equally evaluated, it seems that the crippling financial implications of conventional recovery, conservation and storage weighed more heavily on the decision than anything else (Cook 2005, p. 165). Regardless of the factors influencing their decision, the archaeologists at Parks Canada designed a reburial scheme that was meant to ensure ‘the condition of the wreck and the environment that surround [sic] it can be monitored to insure [sic] that the original preservation intention of the reburial is being met’ (Stewart, Murdock & Waddell 1995, p. 794). The burial mound consisted of a 1-1.5 metre mound of sand covered by synthetic rubber tarpaulin and anchored with concrete-filled tyres (Stewart, Murdock & Waddell 1995, p. 796). This design accounted for many environmental aspects, including the movement of icebergs in the area. These icebergs have been known to scrape deep channels into the seabed and it was hoped that the addition of the tyres would prevent such damage (Stewart, Murdock & Waddell 1995, p. 795).

The Parks Canada Conservation Division was charged with managing conservation and monitoring (Cook 2005, p. 165; Stevens 1981, p. 36). Dipwells
were installed at the time of reburial, which allowed for water samples to be collected and analysed *ex situ* for dissolved oxygen, pH and the presence of other chemicals such as nitrogen, iron and phosphates (Stewart, Murdock & Waddell 1995, pp. 798-799). Measurements of dissolved oxygen taken in 1986, one year after the reburial, showed that the mound had become suboxic (Stewart, Murdock & Waddell 1995, p. 798). Sacrificial wood samples were placed throughout the burial mound while control samples were kept in the laboratory (Stewart, Murdock & Waddell 1995, p. 798). Relative density and percentage loss of wood substance were measured in 1992. The extent of deterioration of timber samples after seven years was negligible (Stewart, Murdock & Waddell 1995, pp. 800-801). Cook (2005, p. 165) mentions that the site is monitored every five years and that analysis is being conducted by Parks Canada conservation scientists. However, whether this programme remains current and what results are being obtained is difficult to say. Recent results would be helpful for the study of reburial as an *in situ* preservation method. Parks Canada continues to use similar reburial methods on underwater cultural heritage, such as on the shipwreck *Elizabeth and Mary*, in Baie-Trinité, Quebec (Bernier 2006, p. 64).

*HMS Pandora* was also reburied, using backfill (Gesner 1993, p. 10; Gesner 1990, p. 41). This process was carried out both during the excavation season, where portions of the vessel were exposed more than once, and at the end of the season to protect exposed portions between excavations (Gesner 1993, p. 9). While this is not the same type of permanent reburial as the Red Bay example, the basic idea is similar: to encourage an anoxic reburial environment and to physically protect the wooden hull from aerobic marine borers and the ravages of water movement. Questions arose during this process as to whether or not the use of backfill was detrimental to the long-term survival of the vessel. During the 1993 season, microbiological analyses were conducted in several areas on and around the wreck in order to collect data about the microbial communities inhabiting the sediment (Guthrie et al. 1994, p. 19). The inclusion of microbiologists on the project points to recognition of *in situ* preservation as being experimental where scientific data is needed to ascertain whether or not the reburial environment is conducive to artefact preservation in the long-term.
Sandbags are also used to rebury sites. Sandbags have the added advantage of acting as supportive structures for features and artefacts on site, such as hull structures (Hosty 1988, p. 14). On William Salthouse in Port Phillip Bay, Victoria, sandbags were employed to support the collapsing hull structure and aid in trapping sand after a variety of techniques, such as fencing, mesh sediment traps and sediment drops were unsuccessful (Hosty 1988, p. 13; Staniforth 2006, p. 54). While the hull did remain stable with the support from the sand bags (Hosty 1988, p. 16) and some areas experienced an arrest in scouring (Harvey 1996, p. 3), there were issues with the technique which the project members noted at the time: the impermanence of the sandbag solution due to the requirement to use biodegradable materials, the possibility of strain on other sections of the hull and the likelihood of secondary, or toe, scour caused by the sandbags themselves (Harvey 1996, p. 4; Hosty 1988, p. 16). In this instance, the use of sandbags was intended as an interim solution while more permanent measures were explored (Harvey 1996, p. 4; Hosty 1988, p. 16). This was also the case on James Matthews in Fremantle, Western Australia (Godfrey et al. 2005, p. 42).

Sandbags are often considered a cost-efficient way of stabilising and preserving sites. This method, however, seems to be a temporary measure. It is necessary to understand fully both the site requirements and the long-term costs of any necessary replacements in terms of materials, time and personnel (Oxley 1998b, pp. 166-167). Other projects have utilised sandbags. On a seventeenth-century wooden vessel at Duart Point in the Sound of Mull, Scotland, they have been employed to reduce erosion and protect exposed hull structures between survey seasons (Gregory 1995, p. 64; Martin 1995, p. 19). Martin (1995, p. 30) indicated that the sandbags protected the site in the short term but that a full rescue archaeology excavation may be the only way to manage this cultural resource. Sandbags on the Sydney Cove wreck off Preservation Island, Tasmania, have assisted in retaining the re-deposited sediment on site in conjunction with protective netting (Nash 2006, p. 64; Nash 1991, p. 40) and reducing the physical effects of current on the site (McCarthy 1986, p. 133).

Another method of encouraging sediment deposition that has been successful in certain situations has been artificial seagrass. Seagrass occurs naturally on many sites, but once disturbed, is unlikely to re-establish itself (Godfrey et al. 2005, p.
There has been limited success in some areas, such as the Biscayne National Park, Florida, with replanting turtle grass (Skowronek et al. 1987, p. 317). The lack of success in repopulating the seabed with other forms of natural seagrass necessitated a different approach to protective covering. Mats of artificial seagrass, created from polymeric materials, can be assembled and positioned on the seabed (Staniforth 2006, p. 54), acting in a similar manner to natural seagrass, encouraging sediment deposition. A variety of artificial seagrass constructs were created by a number of engineering companies in order to counter shoreline erosion and were quickly applied to offshore structures such as pipelines and oil platforms (Moran 1997a, p. 133; Pilarczyk 2000, pp. 697-700). The Ceggrass Erosion Control System, by Cebo UK Ltd, was trialed on William Salthouse (Harvey 1996, p. 4; Oxley 1998b, p. 167; Staniforth 2006, p. 54). The Ceggrass proved successful, with some minor adjustments. Control of scour and increased sediment deposition was almost immediate (Staniforth 2006, p. 54). By monitoring the site, personnel were able to note areas of scouring that did occur and make necessary adjustments, such as adding a new mat and filling in a larger scour hole with sandbags and sediment (Harvey 1996, p. 7). On William Salthouse, artificial seagrass was determined to be successful in preserving the site in situ in the medium term (Harvey 1996, p. 7), though on-site monitoring in 2008 indicated that scouring was occurring again (H. Steyne 2008, pers. comm., 24 September).

Artificial seagrass does, however, have its disadvantages and challenges. Site conditions such as seabed slope, speed and direction of current must be considered. For example, sites with slow current, such as the Legare Anchorage site in Biscayne National Park, Florida, often have a build up of biological deposits on the fronds, halting sediment deposition (Skowronek et al. 1987, p. 317). As with sandbagging, a thorough knowledge of the environmental conditions on site is imperative. Purchasing, transporting and deploying proprietary artificial seagrass systems is also cost intensive (Harvey 1996, p. 7), and relies heavily on volunteers. The Western Australian Museum developed a cost-efficient “in-house” system for use on James Matthews, which was also easily deployed by two divers (V. Richards 2008, pers. comm., 10 November). The Ceggrass system used on William Salthouse also employed a steel mesh base,
the corrosion of which has implications for the microenvironment and may be
detrimental to the reburied artefacts. Artificial seagrass systems used on
archaeological sites would need to be manufactured from materials that would not
have adverse effects on the cultural resource.

Geotextiles have also been used to protect sites and encourage sediment
deposition. Near Zakynthos harbour in Greece, a wreck dating to the fifteenth or
sixteenth century has been protected through the use of Terram 4000, a textile
created from polyethylene and polypropylene (Pournou, Jones & Moss 1999, p.
58). Terram was chosen in this particular project to protect the site between
excavation seasons as reburial would have added an extra burden in terms of
removal time (Pournou, Jones & Moss 1999, p. 58). Prior to being used on the
wreck, different grades of Terram were tested for permeability, resistance to biota
and resilience. Terram 2000 and 4000 were then trialed on site where Terram
4000 was chosen based on positive results of wood and sediment analysis
(Pournou, Jones & Moss 1999, pp. 59-61). On the Zakynthos site, samples were
taken during the monitoring of the site, including wood samples, which were
studied for wood degrading micro-organisms, and sediment cores, which were
analysed for micro-organisms and physico-chemical composition. Redox
potential, pH and dissolved oxygen were also measured (Pournou, Jones & Moss
1999, p. 59). These analyses allowed the use of Terram to be semi-quantitatively
considered in terms of success. The results showed that Terram induced an anoxic
environment, which protected the ship’s timbers primarily from biological attack,
though chemical deterioration appeared to have slowed also. Another advantage
of the Terram covering proved to be the protection of the timbers from physical
deterioration due to excessive water movement.

In the Netherlands’ Wadden Sea, a seventeenth-century Vereenigde Oost-Indische
Compagnie (VOC) vessel has been protected by a combination of sandbags and
georxivnete netting since the late 1980s (Manders 2006a, p. 70), becoming the
Netherlands’ first ship protected in situ. Since the original method was employed,
monitoring has shown the sandbags to be redundant. The polypropylene netting
now is used alone. When deployed loosely, the netting moves freely in the water,
capturing sand moving across the site. As with seagrass, the sediment is slowed
until it drops from the water column creating a sediment mound that protects the
wreck from marine borers and fishing nets (Manders 2006a, p. 72). This project also used a data logger to monitor changes in the environment such as pH, temperature, dissolved oxygen and turbidity. Importantly, samples of wood placed within aerobic and anaerobic areas of the site allowed for the monitoring of deterioration rates. Many of the changes to the procedures used on this site have been as a result of international projects aimed at understanding the scientific processes of in situ preservation (Manders 2006a, p. 72). As a result of the successful use of netting, it has been employed on other sites, such as the Sri Lankan wreck site of Avondster, another VOC vessel (Manders 2006b, p. 58). Davide (2002, p. 83) reports that netting, along with sandbagging, is also one of the most common methods of in situ preservation used in Italy, but notes that while it is cost effective, it requires replacing as it disintegrates easily.

**Cathodic Protection**

Cathodic protection is another method of protecting submerged sites, in particular those with large metal artefacts (Oxley 1998b, p. 165). A sacrificial anode comprised of a more easily corroding metal, often zinc, magnesium or aluminium, is placed in electrical contact with the object to be protected. The two form an electrochemical cell in which the anode, having a higher negative potential, actively corrodes, in preference to the cathode, which is in turn protected (MacLeod 1987, p. 51; Oxley 1998b, p. 165). Like artificial seagrass, this method has been used extensively in a number of other marine capacities, such as in the protection of working vessels, jetty piles and oil platforms (McCarthy 2000, p. 87). Australia was one of the first countries to actively pursue cathodic protective methods, with a number of sites currently protected in this fashion. The start of this type of preservation can be traced back to research carried out by the conservation team at the Western Australian Maritime Museum. Originally, MacLeod and North pioneered the use of anodes to stabilise metal objects such as engines, anchors and cannons prior to retrieval (MacLeod 1996b, p. 1; MacLeod 1993, pp. 223-224; MacLeod 1992, p. 15; MacLeod 1987, pp. 50-51). On the Sirius site off Norfolk Island, New South Wales, this type of pre-treatment successfully stabilised an extensively corroded carronade (MacLeod 1992, p. 15). This demonstrated that the use of sacrificial anodes on sites could not only slow deterioration and help preserve metal on the seabed, but also reduce conservation
treatment times post-excavation. This method does require monitoring as the anodes have a limited working life and need to be replaced at regular intervals to ensure continued protection. On the Yongala site, for instance, it was decided that sacrificial anodes would not be used due to limited time, personnel and financial factors (Viduka 2006, p. 62).

McCarthy (1987, p. 11) reported that sacrificial anodes on the stern of the Xancho allowed portions of the wreck to remain in situ for the enjoyment of recreational divers, although the original intent of the anodes was to prepare the stern for eventual recovery (McCarthy 2000, p. 145). In the 1990s, sacrificial anodes were attached to Zanoni and monitoring in 1998 showed that active corrosion of the iron portions of the vessel had slowed after the attachment of the anodes (MacLeod 1998, p. 83). However, the advanced state of deterioration of Zanoni meant that it was still very fragile and could be easily disturbed by natural or human impact (MacLeod 1998, p. 83). Another wreck that has been protected by anodes is the Duart Point wreck in Scotland (Gregory 1999, p. 164) mentioned previously. Florida has also used anodes to protect anchors on underwater preserves created by the state (D. Scott-Ireton 2008, pers. comm., 22 September).

**Chemical Methods**

Oxley (1998b, p. 167) also mentions the use of chemical coatings to preserve materials such as the wooden frames of vessels. In the 1970s, tributyltin oxide was used on the wreck of the Rapid. While it appeared that the extent of biological activity decreased due to the toxicity of TBTO, this method is no longer used. Most nations, including Australia, New Zealand (Australian and New Zealand Environment and Conservation Council 2000) and Canada (Department of Justice 1985; Environment Canada 1999), have since developed extensive laws pertaining to the use of chemicals in the oceans and rivers, especially those known to be toxic to marine life and humans. This is also an issue when dealing with barrier methods that employ plastics or polymers treated with chemical preservatives (Hosty 1988, p. 14; Pournou, Jones & Moss 1999, p. 58). Due to the environmental restrictions and health hazards, the use of chemicals is not seen as a viable option for in situ preservation.
Discussion

Searching the literature reveals that there are many projects worldwide that employ various methods or combinations of methods for *in situ* preservation. Some have met with considerably more success than others. Often these methods are in response to some type of emergency, such as impact on the site by recreational divers. This tends to lend an appearance of a “trial and error” approach to preserving sites (Hosty 1988, p. 13; Moran 1997b, p. 129). As Godfrey et al. (2005, p. 40) and Oxley (1998a p. 117; 1998b, p. 170) suggest a more in-depth and complete assessment of both sites and methods is required to ensure that *in situ* preservation techniques are more successful in the future. As was seen with William Salthouse, a number of techniques were employed before a solution was found (Harvey 1996, p. 1). An important element of this project, however, was the initial recognition about the limitations of at least one of the chosen techniques (sandbagging) and the understanding that this technique was employed temporarily to enable further research into a more permanent method.

One area in particular that should be more closely examined before any *in situ* method is employed is the environment of the site itself. In order to make the best decision for the site, a full survey focusing on environmental and conservation factors should be undertaken (Godfrey et al. 2005, p. 40; Oxley 1998b, p. 170). The type of sediment, the amount of dissolved oxygen, the strength and direction of currents and the overall deterioration of the site are some of the many things that are important in order to understand what techniques will be most successful. Unfortunately, these surveys are rarely mentioned in the literature. This makes it difficult to gauge how extensively or regularly these surveys are carried out. Godfrey et al. (2005, p. 40) provided an in-depth conservation survey of the *James Matthews* site, exploring each group of artefacts in terms of degradation. This represents the type of intensive survey that is required in order to make the best decision for every site. Some environmental sampling was undertaken on *Pandora* (Guthrie et al. 1994, p. 19), but only after backfilling had taken place on the site and focused mainly on the microbial communities in the sediment without any sampling of the timbers themselves.
Understanding the advantages and disadvantages of the techniques is also a major element of employing *in situ* preservation. This will require further experimentation, such as those underway in the projects to be discussed in Chapter Three. The results should outline not only cost-effective strategies but also which methods are appropriate for different environments. As Oxley (1998b, p. 170) points out, continuing to liaise with other industries such as oil and gas will be beneficial, especially in a discipline that does not generate cash flow easily. It is also important to develop strong links with other disciplines involved in similar research in the scientific community, such as wood science, microbiology, chemistry and oceanography. These groups are, as a whole, more likely to raise the necessary funds for both short- and long-term experiments.

Another shortcoming noted in the literature is the lack of continued monitoring and publication of results. The Parks Canada Red Bay project has already been noted as one such project, which in many ways was meant to showcase a continued monitoring programme intended to add quantitative data to the understanding of the *in situ* process (Cook 2005, p. 165). Lack of funding is likely the most significant factor behind the absence of regular monitoring programmes. There remains the possibility that integral data that may have had significant influences on current and future archaeological projects and indeed any purely scientific research is unavailable. Many of the projects discussed above have not continued to publish the successes or failures of *in situ* methods utilised. The *Pandora* project, for instance, has had no updates published since 1994. A small number of projects, such as *James Matthews*, have continued to publish results about preservation work. The Western Australian Museum, while admitting to being hindered by time, personnel and funding restraints (V. Richards 2008, pers. comm., 21 April), has been vigilant in ensuring that their work is reported, often using conferences as a medium. This could be in part due to the structure of the museum, which includes conservation scientists.

Oxley (1998a) produced a thesis entitled ‘The Environment of Historic Shipwreck Sites: A Review of the Preservation of Materials, Site Formation and Site Environmental Assessment’, which contained a chapter which reviewed *in situ* methods and techniques. In his discussion of the literature, he noted the need for ‘quantified assessment of the stability of…sites, followed by the design and...
implementation of suitable mitigation strategies’ (Oxley 1998a, p. 116). He stressed the need for further research into effective methods and the need for full monitoring and assessment of environmental conditions on sites. Ten years later it is difficult to assess from a review of the archaeological literature how much has changed in terms of collecting information on site that can inform choices for preservation. At present, the gaps in the literature may point to a lack of understanding of the importance of in situ data or the inability to publish results. It could also be indicative of the ‘dichotomy between conservators and archaeologists when dealing with the same materials’ (McCarthy 1987, p. 9), which can hinder progress. If archaeologists are not yet convinced that in situ methods have merit or can be conveniently implemented, the research discussed in the following chapters has the ability to provide some answers to assist archaeologists and cultural heritage managers in tandem with conservators to make the necessary decisions for the successful management of underwater cultural heritage.
Chapter 3: *In Situ* Preservation and Scientific Experimentation

Exploring the Science

Since Oxley’s 1998 Master’s thesis, which in part explored *in situ* preservation practices, perhaps the biggest change has been the advances made in the scientific exploration of methods. Over the last ten years, a concerted effort has been made to investigate many of the preconceptions held by archaeologists and conservators alike about how archaeological remains are preserved *in situ*. These investigations vary from relatively small laboratory studies to large multi-year projects in the field. Many of the personnel involved in these projects are often not archaeologists, but come from a wide range of fields, such as microbiology, geology, chemistry, biology and oceanography. This has brought to the table a vast array of techniques that have provided greater in-depth knowledge of the archaeological materials, the environment and their interaction *in situ*. This, in turn, has led to some interesting developments in understanding *in situ* preservation of underwater cultural heritage. Some of the projects underway have been designed to provide large amounts of data for many years to come.

One of the main criticisms by many of those who work with underwater cultural heritage has been the lack of scientific data that proves *in situ* preservation methods do protect these delicate archaeological remains (Bergstrand & Nyström Godfrey 2007, p. 10; Godfrey et al. 2005, p. 40; Manders 2004b, p. 279; Oxley 1998a, p. 90; Oxley 1998b, pp. 159-160; Winton & Richards 2005, p. 77). Parks Canada’s work at Red Bay was intended to provide scientific data about *in situ* methods. Early publications provided exceptional records of the methodology of a project unique in its scope. Stewart, Murdock and Waddell (1995) and Waddell (1994) presented some information of the sampling methods and the analytical techniques employed in the project, but since 1995 no new analyses have appeared. It may be assumed that one reason for this is that little or no funding has been provided to Parks Canada for continued monitoring. Nevertheless, over the last decade, a number of projects specifically intended to provide results demonstrating the effects of the environment on archaeological materials have
either been completed or are underway. A number of these projects will be discussed in detail in this chapter.

**Laboratory Experiments Focusing on Organic Material**

Most laboratory experiments exploring *in situ* preservation have focused on the mechanisms of wood degradation (Björdal, Daniel & Nilsson 2000; Björdal & Nilsson 1999; Björdal, Nilsson & Daniel 1999; Nilsson 1999). In Björdal and Nilsson (1999), pine sapwood samples were buried in three different sediment types in order to determine which was more likely to cause the least amount of decay. Wet sand, clay and topsoil were used and samples were recovered after three, six and nine months. Topsoil was determined to be the least preserving, while clay and wet sand proved to have higher preservation qualities. This experiment also showed that covering the sediments with either sawdust or geotextile heightened the soils’ protective qualities by inducing an anoxic state.

While the authors focused on the effects of sediment type, microbes, moisture content and dissolved oxygen levels, they noted that pH, depth of burial and hydrological movement would also have direct bearing on the preservation qualities of sediments (Björdal & Nilsson 1999, p. 75).

Following on from this work, Björdal, Daniel and Nilsson (2000) investigated how burial depth affected the microbial decay of archaeological wood. Two poles dating from the Viking period were excavated from clay sediment under five metres of brackish water. Samples were taken from close to the top of both poles and from 40 centimetres below the top sample. These samples were examined using microscopic techniques, maximum water content and ease of penetration with a strong needle. Differences in decay between poles were noted to be most likely related to differing wood species (Björdal, Daniel & Nilsson 2000, p. 22). The study determined that depth of burial did have an effect on preservation, with the lower portions of wood showing better preservation than those located higher in the sediment (Björdal, Daniel & Nilsson 2000, p. 25). A significant finding in this study was the presence of active erosion bacteria in the inner portions of the wood tissue, which were affected by even minimal variations in oxygen levels. This seems to point to the importance of slow decay from anaerobic erosion bacteria and the depth of burial for archaeological materials (Björdal, Daniel & Nilsson 2000, pp. 24-25).
As erosion bacteria are accepted as the main causes of degradation in waterlogged wood under anaerobic conditions, identification of these microbial species has become important. Several experiments have attempted to address this issue (Helms 2005; Helms et al. 2004; Nilsson & Björdal 2008a; Nilsson & Björdal 2008b; Nilsson, Björdal & Fällman 2008). Due to the inability at this juncture to isolate the specific bacteria involved, the classification of “erosion bacteria” is based on the way in which the bacteria attack the wood (Nilsson 1999, p. 65).

Using samples from a 1700-year-old spear shaft excavated from Nydam Mose, a team in Denmark cultured bacteria from the interior of the spear under anaerobic conditions (Helms et al. 2004, p. 79). The culture media was supplemented with cellulose degradation products. Chloroform extraction and polymerase chain reaction (PCR) amplification was used to amplify and clone 16S rRNA genes (Helms et al. 2004, p. 81). From the clone library, a number of 16S rRNA genes were sequenced and analysed. Results showed that a wide range of anaerobic bacteria or bacteria that prefer anaerobic environments were present in the archaeological wood and were able to be related to bacteria known to consume cellulose (Helms et al. 2004, p. 87). Helms (2005) has continued to work on this matter through a PhD dissertation with the intent to provide standardised methods of extracting and analysing bacterial DNA in archaeological wood. This work has noted it will be necessary to identify and isolate those bacterial species that degrade cellulose from those which degrade wood (Helms 2005, p. 125).

**Field Experiments Focusing on Organic Materials**

Experimental studies have also taken place in the field. Some have been characterised as short-term studies while others, discussed later in this chapter, have been extensive and long-term. One such short-term experiment was conducted at Lynæs Sands in Denmark (Gregory 1999b; Gregory 1998). The area was chosen due to ease of access and the fact that the sandy sediment had yielded good preservation results previously (Gregory 1999b, p. 78). Dissolved oxygen contents, pH, redox potentials, ammonium and nitrate concentrations were measured (Gregory 1998, p. 346). Sapwood oak samples were used in the experiment and placed at three different depth intervals: one exposed to seawater, one buried just below the sediment surface and one buried 50 centimetres below the sediment surface (Gregory 1998, pp. 346-347). Using six sets of wood blocks
allowed for samples to be retrieved at four, eight, twelve, sixteen, thirty-two and fifty-two weeks. Results showed that wood borers and soft rot extensively attacked samples exposed to seawater, while those samples buried in sediment escaped this degradation. Those buried just below the surface showed evidence of both marine fungal and bacterial attack, especially tunnelling bacteria, though erosion bacteria may have been present (Gregory 1998, p. 350). Those buried at 50 centimetres showed only minimal attack by erosion bacteria. This led Gregory (1999b, p. 82; 1998, p. 356) to conclude that shallow burial will protect wood from marine borers but not from fungal and aerobic bacterial attack. From this, a recommendation was put forth that archaeological wood be buried below 50 centimetres where only the slow action of erosion bacteria will occur. It should also be noted that there remains questions as to the effects reburial has on already deteriorated archaeological wood (Gregory 1999b, p. 82).

Investigations into the effects of the burial environment on archaeological timber also took place at the Mary Rose site in the 1990s through the analysis of sediment cores (Pointing, Jones & Jones 1997, p. 73). Cores of up to 50 centimetres in length were collected at a number of different levels in the sediment to ascertain possible differences between recent surface sediment at the edge of the site and the redeposited and undisturbed Tudor sediments on the site. The cores were examined for physical, chemical and biological composition. Results from the redeposited sediment sample showed elevated levels of sulphur-reducing bacteria in comparison to the redeposited and undisturbed Tudor samples. This may reflect disturbance during excavation, which may increase microbiological activity (Pointing, Jones & Jones 1997, p. 82). There is a possibility that microflora surviving on archaeological timbers may affect reburial schemes and should be investigated (Pointing, Jones & Jones 1997, p. 84). Pointing, Jones and Jones (Pointing, Jones & Jones 1997, pp. 83 & 85) suggest that reburial be viewed as a long-term storage solution due to the time and personnel required and that reburial on the Mary Rose site in particular avoids burying archaeological timbers on site as remaining artefacts may be compromised.
Experiments Focusing on Metals

As noted in Chapter Two, in situ preservation experiments on metals appear to have started in Australia in the 1980s as a method to assist with conventional conservation by pre-treating metal artefacts while on site (MacLeod 2002, pp. 710-712; MacLeod 1996a, p. 111; MacLeod 1993, pp. 223-224). On the HMS *Sirius* site when an area of concretion was knocked off an anchor, the corrosion rate increased significantly and the area began to flash rust. The application of a sacrificial anode in the form of an aluminium-magnesium engine block helped to stabilise the scar (MacLeod 1993, p. 224). After the anchor was raised for conservation treatment, it was noted that the metal under the concretion had been better protected and that the chloride content of the metal was lower than expected (MacLeod 1996a, pp. 111-112).

This led to the installation of sacrificial anodes as a protective measure on a number of Australian wrecks (MacLeod 1998b, p. 81; MacLeod 1993, p. 221). MacLeod also recommended that sacrificial anodes be used on large iron artefacts on the Duart Point site in Scotland. In 1997, corrosion potentials and pH were re-measured on the artefacts in order to assess the success of the applied cathodic protection system through comparison with the same measurements taken in 1994 (Gregory 1999a, pp. 165-166). The results showed that the anodes were successful in slowing the corrosion rates. One of the issues reported when performing corrosion measurements on metal wrecks and artefacts is that the technique itself is destructive (Heldtberg, MacLeod & Richards 2005, p. 80; MacLeod 2002, p. 709). Laboratory studies on iron were conducted at the Western Australian Maritime Museum in conjunction with in situ experiments on *James Matthews* (Heldtberg, MacLeod & Richards 2005, p. 75). Data from both sets of samples were compared and correlations calculated. These experiments have shown that reducing chloride levels in iron artefacts is an integral part of the stabilisation process (Heldtberg, MacLeod & Richards 2005, p. 83).

Similar research has also been carried out on more modern steel wrecks; work on the WWII USS *Arizona* has trialed the use of a minimal impact method to directly measure corrosion rates. Complicating this work is the wreck’s stature as a memorial, forcing archaeologists and chemists to focus on non-destructive techniques (Henderson 1989; Russell et al. 2006, p. 312). Due to the mechanisms
involved in corroding low-carbon steel, methods trialed on iron wrecks were not feasible (Russell et al. 2006, p. 312). While some technological methods such as Ultrasound have been investigated, analysis of the chemical and physical properties of the hull concretion seems at present to be the best practice (Russell et al. 2006, p. 315). Work on this site will have direct application to other steel-hulled wrecks dating to the twentieth century (Russell et al. 2006, p. 318).

As twentieth-century wrecks stand to become increasingly important with the passing of time, it is worth discussing a study conducted on decommissioned naval vessels sunk as artificial reefs between 1997 and 2002. Investigations on these vessels looked at the interactions between the different metals and the marine environment. Results after four years showed that corrosion had indeed begun albeit at a relatively slow rate (MacLeod et al. 2005, p. 72). While the focus of this monitoring is to assess the impact of the vessels on the local environment and provide information as to their longevity as diving tourist attractions, there are obvious archaeological implications. The ability to monitor the deterioration of a vessel from the wrecking event, through its many complex stages, will no doubt provide useful data for developing *in situ* preservation strategies (MacLeod et al. 2005, p. 53).

**Research into Archaeological Environments and Sampling Methods**

A large body of literature exists within natural science disciplines which explores what parameters are important to sample and monitor in the marine environment and the various methods that have been developed for both waterlogged terrestrial and underwater sediments. This literature is beyond the scope of this thesis. However, by building upon previously recognised and tested procedures developed in these other disciplines, the archaeological environment has been explored in terms of its biology and chemistry (Caple 1998; Caple, Dungworth & Clogg 1997; Hopkins 1998; Pollard 1998). Understanding the complex interactions taking place in sediments is an important aspect that will dictate the success of reburying archaeological remains, especially in waterlogged environments as water and dissolved oxygen play important roles in much of the chemistry and biology (Caple, Dungworth & Clogg 1997, p. 57; Holden et al. 2006, p. 59; Hopkins 1998, p. 73; Pollard 1998, p. 60). Areas where continued research is necessary include the effects of fluctuations in the moisture content of
sediments; redox conditions in sediments, salt and fresh waters; speciation of metal ions; pH of sediments and solutions; and the effects of temperature change and salinity (Caple 1998, p. 113; Holden et al. 2006, p. 59; Pollard 1998, p. 60).

Sampling methods and analytical techniques continue to be tested and revised, allowing for more accurate measurements and an increase in the amount of applicable data. Data loggers, while still developmental in some aspects, can be deployed on terrestrial and submerged sites in conjunction with dipwells to collect data, such as temperature, pH, dissolved oxygen contents and redox potentials (Bergstrand & Nyström Godfrey 2007, 26-27; Gregory 2007, p. 5-8; Palma 2004, p. 10; Palma, Gregory & Jones 2005, p. 680). Redox potentials, dissolved oxygen and pH have been measured in the laboratory with microelectrodes from sediment core samples (Gregory 2007, p. 8). Other parameters measured ex situ using wet chemical methods include ion, mineral and organic content. The results gathered from the datalogger were not completely dependable or accurate, but Gregory (2007, p. 29) notes that improvements will no doubt continue to be made.

Large Scale Projects

For the purposes of categorisation, projects denoted as “large scale” are those projects that, rather than focusing on one material, method or sampling procedure, opt instead for a more holistic approach. This allows for the investigation of many aspects of in situ preservation in one project over an extended period of time. The projects discussed here do not necessarily take place on an archaeological site, though some do. In most cases, combinations of modern and archaeological materials are examined and differences in environments may be explored. Again, an important characteristic of these projects is the interdisciplinary approach.

James Matthews

The work on James Matthews is, perhaps, one of the more difficult to categorise. On the one hand, it should fall under the category of archaeological projects and, in this capacity, was discussed in Chapter Two. However, it is also in many ways more characteristic of the other larger projects discussed here in that one of the main goals, beyond preserving underwater cultural heritage, is to “understand the deterioration processes and the environmental effects on a site” (Godfrey et al. 2005, p. 40). The conservation survey and monitoring programme instigated on
this site was comprehensive, investigating all aspects of the wreck and its
environment in order to assess current reburial schemes and to make informed
suggestions about necessary changes and updates.

The history of the project provided by Godfrey et al. (2005, pp. 41-43)
demonstrates developing thought patterns about in situ preservation. Reburial
during the 1970s excavations was not monitored. Work undertaken during 2000
and 2001 included on-site sampling and the introduction of conservation
monitoring programmes (Godfrey et al. 2005, p. 43). At that juncture, test pits
were dug to ascertain both the deterioration of the ship’s timbers as well as
measure a number of environmental parameters at various depths. Analyses of
these samples allowed personnel to understand the nature of the site and the
impact the environment had on the preservation of the vessel. The implementation
of such programmes provides the knowledge to make informed decisions about
the types of protection possible for the site in the future. In this case, it was
decided that the best possible scenario for the in-situ preservation of James
Matthews was to encourage sediment deposition and retention (Godfrey et al.
2005, p. 64).

As will no doubt continue to be the case in developing in situ preservation plans
for underwater cultural heritage, temporary measures were taken in the form of
sandbags and shade cloth in order to permit a more permanent solution to be
found while continuing to protect the resource (Godfrey et al. 2005, p. 64; Winton
& Richards 2005, p. 79). Suggestions for the future have included placing plastic
“crash barriers”, used on roads, around the site as a cofferdam, with sand
deposited inside to the required depth and protected with a geotextile such as the
Terram 4000, previously trialed in Greece (Pournou, Jones & Moss 1999, p. 58).
Trials of the crash barrier method commenced on a different site in 2003 (Godfrey
et al. 2005, p. 65). With some modifications, such as ensuring the walls were
rendered solid and preventing the sediment from escaping through small gaps in
the walls, the road crash barrier technique appeared successful (Winton &
Richards 2005, pp. 86-87) and may well be a solution for preserving James
Matthews.
An integral part of this project has been the recognition of the importance of a continued monitoring programme, both in order to provide the best method of protection and to ensure the continued success of that chosen mitigation strategy (Godfrey et al. 2005, p. 65; Manders 2004a, p. 75). Continuity with the 2000 on-site conservation study has been built into the programme and specific timing for sampling has been developed. The inclusion of sacrificial samples to determine rates of deterioration will aid in understanding the site dynamics and deciding the success of the chosen programme (Godfrey et al. 2005, p. 67).

**Nydam Mose**

*In situ* preservation projects for underwater cultural heritage have been supported by research conducted on waterlogged terrestrial sites. Experiments at Nydam Mose, an Iron Age sacrificial lake in Denmark, have focused on environmental sampling methods and the deterioration of materials, particularly wooden artefacts, in waterlogged environments (Gregory, Matthiesen & Björdal 2002; Matthiesen et al. 2004). While sampling techniques used in terrestrial circumstances may not, in some cases, be directly applied to underwater sites, the types of sampling executed, possible means of contamination and the analyses conducted are pertinent to environmental sampling undertaken on submerged resources. Comparing results of environmental analyses from Nydam Mose with submerged data sets may help to elucidate the mechanisms of deterioration in waterlogged sediments.

Also underway at Nydam Mose is the degradation study of archaeological and modern materials (Gregory, Matthiesen & Björdal 2002, p. 213; Matthiesen et al. 2004, p. 57). This methodology is similar to other investigations underway in Northern Europe (Bergstrand & Nyström Godfrey 2007; Bergstrand et al. 2005; Cederlund 2004; Manders 2004b), which will enable the results of each project to be compared and possible hypotheses drawn about the effects of environmental parameters on the deterioration of archaeological materials. Again, an important part of these projects is the collaboration between members of several disciplines.

**BACPOLES**

“Preserving cultural heritage by preventing bacterial decay of wood in foundation piles and archaeological sites” (BACPOLES) is another project, sponsored by the
European Union, which explores deterioration in archaeological wood. This project has both wet and dry terrestrial and submerged components and focuses on bacteria found in anaerobic environments responsible for the slow deterioration of wood (Manders 2004b, pp. 285-287). As previously noted, the specific bacteria responsible for this decay have yet to be isolated or identified (Manders 2004b, p. 285; Helms 2005, p. 119; Helms et al. 2004, p. 79). Nevertheless, BACPOLES has made significant headway in investigating this issue, trialing new isolation techniques such as the use of purified active consortia (Nilsson & Björdal 2008a, p. 3). It is hoped that using live bacteria will facilitate identification (Nilsson & Björdal 2008a, p. 8). Among the maritime sites were the wrecks Stora Sophia and Kronan in Sweden and four wrecks in the Netherlands, including what is possibly the VOC ship de Rob in the Wadden Sea (BACPOLES, n.d.). Huisman et al. (2008, pp. 41-43) have reported possible correlations between erosion bacteria and the redox conditions inside archaeological wood. This may contribute to the elevated sulphur content in wood that appears to be a factor in causing post-conservation problems with the recovered vessels, such as Vasa and Batavia.

MoSS

“Monitoring, Safeguarding and Visualising North-European Shipwreck Sites” (MoSS) was a second European Union project that focused on the protection of cultural heritage. Unlike BACPOLES, this project centred around submerged heritage. Aimed at understanding the processes of degradation on shipwrecks, it also incorporated an important issue in cultural heritage management: public awareness as a method of preserving shipwrecks (Manders 2004b, p. 280; Manders & Luth 2004, p. 63). Another important aspect of this project was its intention to investigate a number of different environments in order to create a practice that could be applicable in a number of circumstances (Alvik & Tikkanen 2004, p. 3). Several countries were involved in this project, including Sweden, Germany, Denmark and the Netherlands. Three shipwrecks underwent scientific sampling and monitoring with data loggers: Vrouw Maria in Finland, the Darss Cog in Germany and Burgzand Noord 10 in the Netherlands. The wreck of Eric Nordevall, in Sweden, was only monitored visually. The dataloggers collected information on currents, salinity, dissolved oxygen, redox potentials, pH,

Monitoring of the deterioration rate of wood was also employed at each site with samples of modern wood being prepared and placed in both aerobic and anaerobic environments (Palma 2004, p. 10). Samples were collected at specified times and underwent a battery of tests, including photography, x-ray, scanning electron microscopy (SEM) and light stereo microscopy (Palma 2004, p. 11). These tests allowed the samples to be analysed for a number of determinants of degradation such as biological attack, moisture content and density (Palma 2004, p. 12). This project not only provided information about the natural environment extant on a wreck site, aerobic and anaerobic, but was also able to evaluate the use of sediment trapping by debris netting on the Darss Cog and the Burgzand Noord 10 as an in situ preservation method. This in turn was contrasted with the wrecks of the Vrouw Maria and Eric Nordevall, neither of which could be protected in this manner (Manders & Luth 2004, p. 67-68).

**RAAR**

“Reburial and Analyses of Archaeological Remains” (RAAR) is a study taking place in Marstrand, Sweden, designed to span 50 years in order to explore the long-term outcomes of reburial on archaeological materials. Separated into sub-projects, RAAR examines the degradation of materials commonly found on archaeological sites (Bergstrand et al. 2005, p. 20). During excavations of the eighteenth century vessel Fredricus, reburial was designated as the preservation method of choice. Two trenches were dug “in close proximity to the excavation site; [sic] one for metals only (predominantly iron) and one for all other materials” (Bergstrand & Nyström Godfrey 2007, p. 13). After documentation, 85% of the finds would be reburied, with the remaining 15% undergoing conventional conservation (Bergstrand et al. 2005, p. 11). RAAR placed mostly modern experimental samples in the unused portions of these trenches, including wood and metal samples at various levels above and below the sediment (Bergstrand & Nyström Godfrey 2007, p. 20). Over the next 48 years, at pre-determined times, samples will be removed and analysed. Phase one covered the three-year period between 2002 and 2005. Even within this short time period, analyses of the recovered samples have produced some surprising results.
Appendix One of the major report addresses the environmental monitoring sub-project which is significant as it not only assesses the environmental parameters on the reburial site, but trials methodology in order to improve data collection (Bergstrand & Nyström Godfrey 2007, p. 18; Gregory 2007, p. 4). In tandem with material sampling, numerous environmental parameters were sampled seasonally both *in situ*, by means of an EauxSys UK data logger, and *ex situ*, from sediment cores analysed in the laboratory with several different microelectrodes (Gregory 2007, p. 5). The data logger has provided useful information about seasonal changes, though the sensors have proved to be unreliable and maintenance of the unit expensive in terms of time and money (Gregory 2007, p. 25). The sediment cores were on the whole successful, though Gregory (2007, p. 25) notes core samples extending deeper than 50 centimetres are required for analysis in the future. Modelling based on the measurements taken in the organic trench has predicted a very slow rate of deterioration due to the relatively rapid establishment of an anoxic environment (Gregory 2007, p. 29).

The metals sub-project aims at assessing the corrosion of metals buried in marine environments, an area which has been subject to few such investigations (Bergstrand & Nyström Godfrey 2007, pp. 10 & 16). The metal samples used were modern ferrous and cupric alloys of known composition, mounted and reburied separately to offset the galvanic effect of different metals on one another. Three sets of coupons were used per metal type in order to study the consequences of different depths on the corrosion of the coupons (Richards & MacLeod 2007, p. 1). The results of the metal analyses, covering two years rather than three, have proved interesting. Results have suggested the use of packaging materials will be of significant importance in preserving metals through reburial by ensuring physical separation of objects as well as providing protection from abrasion (Richards & MacLeod 2007, p. 81). These preliminary results also show that the previously held conception of reburial at 50 centimetres may not be suitable for metals, and burial depths greater than 50cm may be required for good long-term preservation, especially for ferrous alloys (Richards & MacLeod 2007, p. 82). However, Richards and MacLeod (2007, p. 82) suggest the continuation of this project and further research as the results are so far inconclusive.
The sub-project examining the reburial of glass and ceramics has also produced some unexpected results in the first three years. Archaeological and modern samples were used in this experiment and packaging was included (Bohm et al. 2007, p. 4). All samples were placed at a depth of 50 centimetres. Results have shown that the inclusion of modern samples has been invaluable as archaeological samples have been difficult to assess except by comparison (Bohm et al. 2007, p. 24). Based on the results, Bohm et al. (2007, p. 25) recommend that glass and low-fired ceramics should not be reburied and again the continuation of the investigation is urged in order to assess long-term effects of chemical and physical degradation on glazing and high-fired ceramics.

While the degradation of wood during reburial has been investigated more often than other materials in the past, the long-term aspect of RAAR provides new testing grounds. Using several species, modern samples were exposed to the seawater environment, buried just below the sediment and at 50cm below the sediment surface. Samples were collected on four occasions within the three-year period (Björdal & Nilsson 2007, p. 2). Using light microscopy, microbial decay was assessed and comparisons were made to time and depth of burial (Björdal & Nilsson 2007, pp. 3-4). There appears to be an inverse correlation between depth of burial and decay over time. The deeper the wood is buried, the slower the decay processes. Conversely, wood samples left on the surface of the seabed experienced a much quicker and intense process of decay (Björdal & Nilsson 2007, p. 4). This has led to the confirmation of the minimum 50 cm burial depth, with the caveat that further investigation explores reburial below 50 cm in order to define optimal depths (Björdal & Nilsson 2007, p. 5). Suggestions for the future include the continuation of this project at a more detailed level in order to model decay over time (Björdal & Nilsson 2007, p. 5).

The fifth sub-project focuses on organic materials other than wood. Fifteen samples of a variety of organics were prepared, with two samples for each retrieval period; one sample remained uncovered while the second was covered with nylon-mesh and geotextile (Peacock 2007, pp. 5-6). Results from the first phase have led to recommendations against the reburial of fibrous organics, such as tarred cotton fishing net, hemp rope and linen (Peacock 2007, p. 25), while further research is needed to assess the long term survival of leather, bone, antler
and horn (Peacock 2007, p. 29). The nylon-mesh and geotextile did hinder degradation, but only while they remained impermeable (Peacock 2007, p. 29). As with most of the materials, increasing the depth of burial led to a decrease in deterioration (Turner-Walker 2007, p. 62).

*In situ* storage containers, packaging and labelling materials have been included as the sixth sub-project, allowing scientists to test how these materials degrade in the reburial environment and the impact this may have on the storage regime used for archaeological materials *in-situ* (Bergstrand et al. 2005, p. 39; Nyström Godfrey et al. 2007, p. 4). Many different types of containers, separating and supporting materials, tags and marking implements, made from a variety of materials, mainly polymers, were investigated (Nyström Godfrey et al. 2007, p. 4). The materials were subjected to three different environments: exposed in seawater, buried in sediment at 50 centimetres and controlled laboratory conditions with accelerated aging experiments. The materials were then examined for chemical and microbiological degradation as well as tested for loss of strength. Some problems were highlighted, including the differences in products made from the same base material that make it difficult to draw conclusions that apply across the board (Nyström Godfrey et al. 2007, p. 43). Again, the team recommends further research.

**Discussion**

As the literature review demonstrates, efforts are being made through laboratory and field projects to increase understandings about the processes active in *in situ* preservation and storage. The development of projects such as RAAR and work on archaeological sites like *James Matthews* have begun to provide much needed information. Certainly, gaps do exist in the knowledge base. Some have been addressed in project methodologies while others have not.

One important issue continues to be the lack of knowledge about the long-term effects of *in situ* preservation. At present, no project has yet been underway long enough to collect this range of data. RAAR does, without doubt, stand to provide some of this information. Artificial aging has been used in conjunction with this project on packaging materials in an attempt to hypothesise about future reactions (Nyström Godfrey et al. 2007, pp. 43-44). Both the wood and environmental
monitoring sub-projects have used results to attempt predictions of potential
deterioration (Björdal & Nilsson 2007, p. 5; Gregory 2007, p. 28). The continued
sampling programme stands to provide data that will refine these speculations,
subject to receipt of funding. At present, the Phase 2 sampling scheduled for 2007
has yet to take place as funding was not secured (V. Richards 2008, pers. comm.,
11 November).

One problem embedded within the RAAR programme as well as others that have
used modern samples is that the data collected, while providing a snapshot of the
beginnings of deterioration processes, fail to address possible issues faced when
reburying archaeological materials. Guthrie et al. (1994, pp. 22-23) noted that
sampling done on *Pandora* showed increased bacterial activity in the backfilled
areas, but were unable to determine whether or not it was as a result of the
excavation or a phenomenon already underway. It is imperative that future studies
investigate what effects reburial has on previously buried archaeological remains
as well as modern materials. RAAR contains aspects of this in its methodology, in
particular the use of archaeological silicates, glass and ceramics alongside modern
samples; the ability to access both archaeological wood and metal in the *Fredricus*
deposit also opens avenues in this direction.

Understanding the microbial community within anaerobic sediment will also
provide better understanding of the degradation process, especially for organic
materials. However, certain flaws have been pointed out in regards to work by
14 September). Anaerobic cellulose degraders were specifically selected; while
these may indeed be the source of the degradation, it is possible that they are not.
The authors do admit this possibility. What is unfortunately not mentioned is that
they cannot guarantee, even with careful extraction, the bacteria existed inside the
wood at the time of recovery. Multiple avenues for contamination existed prior to
extraction, such as the method used to pack and store the wood after recovery.
This means that the sample was not kept in strictly anaerobic conditions and the
use of tap water could have flushed out bacterial communities or introduced new
ones. Sampling methods need to be developed specifically for the study of
anaerobic bacteria by ensuring retrieval, storage and processing is strictly
anaerobic. Nilsson and Björdal (2008a, p. 3) trialed isolation and culturing
methods on samples from the BACPOLES project which were received and processed in a matter of days, lowering the potential for contamination.

In general, a strong programme has begun which addresses many of the concerns noted by archaeologists and cultural heritage managers in the literature. Persisting with this interdisciplinary tack should continue to provide substantial amounts of pertinent data that will allow cultural heritage management plans to be formulated with the needs of the individual site in mind. A holistic approach such as this can only improve relations between those who excavate and those who conserve.
Chapter 4: Questionnaires and Attitudes

Developing the Questionnaire

The people involved in the practice of *in situ* preservation and storage are, as noted in the preceding literature review, a varied group with a diverse knowledge base. They work in countries around the world in a number of different areas, such as government heritage agencies, public and private museums, university departments, not-for-profit agencies and consulting firms. As a result, the questionnaire had to be developed in such a way as to be understood by this group, not just in terms of possible language barriers, but also in terms of inclusive definitions.

Preliminary research identified two main theoretical areas to pursue in terms of survey design: attitudes and behaviours. Surveys designed to assess attitudes investigate how existing knowledge affects actions (Alreck & Settle 2004, pp. 13-14). This was intended to highlight the familiarity of practitioners with the literature about *in situ* preservation and storage and its influence on their actions. The second, behavioural survey, was intended to assess questions such as ‘what, where, when and how often’ (Alreck & Settle 2004, p. 20) in order to understand the types of *in situ* preservation and storage methods previously used, those being currently used and what techniques may be used in future. It also allowed for the ability to identify changes in patterns and routines (Alreck & Settle 2004, pp. 20-21).

The definitions presented in Chapter One (See pp. 4&5) were a focal point for developing the questionnaire. This allowed the questionnaire to be analysed alongside the literature review in a consistent manner. It was also intended to focus respondents, hopefully reducing the numbers of varied interpretations that can occur with self-administered questionnaires (De Vaus 2002, p. 49). Defining *in situ* preservation and storage early on in the process also aided in creating indicators that would later be developed into the questions posed.

De Vaus (2002, p. 45) mentions three ways of developing indicators. The first explores existing research for previously developed measures and concepts. This method was partially applicable in this instance. The literature review provided a
number of definitions and concepts such as what types of *in situ* methods are being used and investigated. From this, the methods were developed into indicators of behaviour. In terms of developed measures, no research into attitudes and behaviours of practitioners in this area has been previously conducted. It was not surprising that no such measures existed.

The second method collects data in a less structured form in order to facilitate the understanding of the group to be studied. The group’s thought patterns and actions can then help create questions that are relevant to the subject being explored (De Vaus 2002, p. 45). This combined well with the third method that requires using information provided by those within the group. In this case, personal experience coupled with conversations with a number of individuals practicing both conventional and *in situ* methods helped to guide question formation. In particular, Vicki Richards, a Research Officer/Conservation Scientist with the Western Australian Museum, was able to provide many useful suggestions and criticisms.

Once the concepts and indicators were developed, the next step was to create and group questions in a way that was both logical and easily understood. Questions were formulated in order to fulfill the following: ease of comprehension by participants through clear definition of the subject (Foddy 1993, p. 25), tolerable length and time frame for participants (De Vaus 2002, p. 112), ease of access for participants in terms of language and delivery (Alreck & Settle 2004, pp. 183-186) and straight-forward flow of questions (De Vaus 2002, p. 110). Originally a three-part questionnaire was conceived. This focused on the general properties of the site, the practice of *in situ* preservation and storage and the use of monitoring. This structure stemmed from the fact that it was necessary to understand *in situ* preservation and storage from a site-specific background. As it was possible that one of the measures of use was to be based on the site itself, it was practical to define sites in terms of physical and environmental parameters as well as the types of cultural heritage that may be found within those sites.

The largest portion of the survey focused on what types of *in situ* preservation and storage are utilised and how many practitioners are using these procedures. The questions were developed on the basis that there should exist three types of
practitioners: those who use *in situ* preservation, those who have used it in the past but have changed their minds and those who have never used it. It also stood to reason that there would be a number of factors influencing decisions made against the use of *in situ* preservation and that in many cases it would be unlikely to be a single reason. It was from discussions of this issue with Vicki Richards (2008, pers. comm., 21-23 April) that a format evolved that allowed for the use of mainly multiple response questions, including the ability for respondents to provide an answer not specified in the questionnaire. This proved useful as these answers demonstrated the far-ranging ideas about the topic.

The third section of the questionnaire focused on monitoring sites. Early on, the decision was made to allow respondents who do not use *in situ* preservation and storage to answer questions in this section. This was based on personal experience with not-for-profit volunteer organisations, such as the Underwater Archaeological Society of British Columbia and the Nautical Archaeology Society. These groups are an integral part of protecting underwater cultural heritage. Monitoring programmes are of primary importance where society mandates focus on preserving heritage. While monitoring in itself may not actively preserve the site, it is an integral part of the *in situ* process and due to the assumed cost efficiency inherent in engaging the existing volunteer base, it was assumed to be one of the more well-utilised methods.

It was after these sections were formulated that the idea for exploring the respondents’ backgrounds began to germinate. As the development and use of *in situ* preservation and storage is a multidisciplinary one, patterns could possibly be brought to light about how the different careers and sectors viewed these methods. Two introductory questions were created that focused on how the respondents viewed themselves in terms of their profession and sector. In this instance, respondents were asked to choose one answer for each question that they felt best described their situation. Some respondents did choose to provide their own answer and these were often a combination of more than one area. The answers to these two questions allowed for more specific analyses to be completed.

In order to use a questionnaire within any research project at Flinders University, ethics approval must be sought. In this case, an application was made to the Social

Limitations are expected with surveys. Those identified as issues in this questionnaire included failure of participants to respond (Alreck & Settle 2004, pp. 37 & 205), individual participants interpreting questions in different ways (Foddy 1993, p. 189), issues between the relationship of what respondents reported they did and what they actually did (Foddy 1993, p. 3) and misapplying statistical methods to the data (Alreck & Settle 2004, p. 269). Some of these, such as the use of the correct statistical methods, have been addressed through research and questionnaire design as well as understanding the types of questions asked. Others, such as response rates, were accepted as inherent risks to survey methodology.

**Delivering the Questionnaire**

It was determined that the best delivery system for this questionnaire was an online method, using SurveyMonkey™. This allowed participants to access the questionnaire easily and eliminated the inherent problems associated with completing paper questionnaires and return post (Alreck & Settle 2004, p. 183). The online questionnaire also proved to be less expensive. As this was an international questionnaire, the postage costs could have been prohibitive. This may have then affected the number of surveys sent, which would, in turn, affect the number received. Four individuals did request paper copies. Only one was returned by the close of the questionnaire. The cost of these four questionnaires, a combination of domestic and international postage, was $20. The overall cost of SurveyMonkey.com™ for the six-month period necessary to send, receive and analyse the questionnaire was $160, including the extra expense associated with the use of SSL to ensure security for those responding. As 210 questionnaires were sent, online delivery potentially saved $890.

The online delivery system also allowed surveys to be sent and received more quickly than relying on postal systems. Emails containing the survey link were delivered five minutes after they were activated. Respondents could respond as soon as they received their link. The email system in SurveyMonkey.com™ also
allowed for reminders to be sent to those who hadn’t responded. Data was also available for analysis immediately after the questionnaire had been received by the system.

SurveyMonkey.com™ also had the added advantage of aesthetics. The questionnaire had the appearance of having been professionally created. Rather than having to provide detailed instructions on a question-by-question basis, SurveyMonkey.com™ allowed for logic formulas to be applied which guided the respondent to the next logical page depending on the answer provided. The downside to this was the time spent inputting formulas and testing the questionnaire each time a change was made. Furthermore, a second survey had to be created with question-by-question instructions for those who required paper copies.

The analysis tool provided by SurveyMonkey.com™ is relatively simple. It provides basic information about the number of respondents who answered a question as well as the count and percentage for each response. Bar graphs provide visual cues. All questions that allowed the respondent to provide their own response were viewable in a separate window. As a more in-depth analysis was desired, a separate statistical analysis programme was utilised. This created another hurdle as it required the data to be downloaded from SurveyMonkey.com™ into an Excel worksheet. From there the data was edited into a format accepted by the statistics software. This was a time-consuming exercise, which required all questions answered with worded responses to be removed and stored elsewhere.

**Analysing the Questionnaire**

**Software**

SPSS™ Statistics 17.0 (formerly Statistics Package for Social Sciences) was the programme used to analyse data collected from the questionnaire. It allows data to be ordered and processed in a variety of fashions depending upon the type of data used. The appeal of this programme for those who are not statisticians is that the user does not have to perform any complicated mathematics or understand complex formulas. The software completes the statistical calculations. The researcher has only to understand the data, the type of results each calculation is meant to produce and how to interpret them. Outputs include tables and a variety
of graphs. All can be exported into a number of programmes suited to presentation and publishing.

The biggest drawback to SPSS™ was the time-consuming data entry. Once the Excel file was imported, the data needed to be coded in order for the programme to be able to perform calculations. In this particular instance, the multiple response questions posed issues. For every question, each answer had to be set up as a single question and then grouped back together into multiple response sets. This operation had to happen in two separate areas: one for computing the majority of formulas and graphs and another for processing multiple response cross tabulations.

Statistics

This questionnaire was inherently qualitative rather than quantitative. Responses were required to be transformed into numbers, which were simply a way of ordering the data for processing by the software. This type of data is known as nominal data (Argyrous & Argyrous 2000, p. 10). Nominal data limited the types of analysis performed to those that could be executed on single low-level data. This did not, however, preclude thorough analysis. What it did mean was that written responses by respondents were treated differently. In most instances they received two analyses: once as a group entitled “Other” which allows certain numerical concepts such as percentages to be applied and once outside the statistics programme by a qualitative review similar to that used in the literature reviews.

The primary form of analysis used on the questionnaire data has been descriptive statistics, including single variable frequencies and bar graphs; multiple response frequencies and bar graphs; and bivariate and multivariate measures of association such as Cramer’s Vs, lambdas and chi squares (Argyrous & Argyrous 2000, pp. 38-39). Each of these will be defined in terms of methods and interpretation in this section. The following section will present the analyses conducted on the in situ questionnaire data.

Frequency tables, the most common way of depicting data, present results in tabular form showing the number of times a particular score or attribute appears in a data set as either an integer or a percentage. These tables have been used for
both single responses and multiple response sets, accompanied by bar graphs. Both counts and percentages have been used in different areas of the analysis. It is important to note that percentages can mask differences between numbers (Argyrous & Argyrous 2000, p. 46); this is especially true of small data sets, such as this one. Where a small change in number may cause a large and therefore dramatic difference in a percentage, a count will be used. For example, only 13 respondents stated that they have never used in situ preservation and storage. The reasons they have highlighted for this will be presented as a count rather than a percentage in order to avoid confusing data. The frequency tables will provide both counts and percents for reference. Most graphs will display numerical data, though multiple response sets may provide percentages. Not all questions will be illustrated in this chapter. Results in their entirety can be found in Appendix B.

While the majority of bar graphs are simple two-axis graphs demonstrating the frequencies in count or percentage of data in each category, a number of graphs have been created that demonstrate the distribution of cases across the categories of one variable in relation to another. This allows responses to be understood in terms of their relationships to each other, such as which careers were more likely to choose to utilise packaging materials.

Crosstabulations reveal whether or not one variable impacts another (Argyrous & Argyrous 2000, p. 44; De Vaus 2002, pp. 122-123). Based on visual interpretation, crosstabulations highlight whether a pattern exists and generally how strong the relationship is. For example, the relationship between careers and the use of in situ preservation and storage can be explored through this method. Single and multiple responses can be measured in this way.

Measures of association are related to crosstabulations and measure how strongly variables are associated with each other in terms of influencing change through a mathematical formula (Argyrous & Argyrous 2000, p. 153). Those that can be used on nominal data include Cramer’s V, lambda and Goodman-Kruskal tau (Argyrous & Argyrous 2000, p. 154). These will be used in association with crosstabulations.
The Questionnaire Results

The questionnaire was sent to 210 individuals in 12 countries. Eighty-nine individuals responded within the two-month period during which the questionnaire was open. This represents a response rate of 42.38%. Typical response rates for surveys tend to be low (Alreck & Settle 2004, pp. 35 & 205). It is possible this response rate represents a high degree of interest in *in situ* preservation and storage by practitioners. This is, unfortunately, difficult to determine as there are other factors involved. The population size of those interested in the preservation of underwater cultural heritage is small. Many of the respondents knew either the author or the supervisors and, in some instances, all both the author and supervisors, which may have skewed return results. However, the response rate was encouraging.

Out of 89 respondents, eight chose not to complete the questionnaire after beginning it. Two answered only the first two questions, while others dropped out at various points after that. Some respondents chose not to answer individual questions, but this was infrequent and seems not to have affected the results in any way. Some questions appear to be low response rates; this was due to answers to previous questions disqualifying them from answering. Those who were not given the option of answering a specific question due to their previous responses were designated the response of “Not Applicable” as responses are required by the software. However, unless “Not Applicable” appeared as a choice in a question, this response will be disregarded.

It is difficult to assess whether or not the sample is representative of the population. This stems in part from the fact that the total size of the population is difficult to determine. Archaeologists and cultural heritage managers are often required to work in a variety of genres other than maritime, such as indigenous and historic. Conservators also may be specialists or work in a variety of areas. It becomes even more difficult to determine the numbers of those individuals who work in disciplines such as chemistry, biology or oceanography, where interaction and interdisciplinary discourse may occur, whether frequent or infrequent. When all of these factors are taken into account, the sample may be more representative.
of archaeologists, cultural heritage managers and perhaps conservators than other groups.

**Distribution of Sample**

In order to assess the types of respondents, two questions were asked at the outset of the questionnaire. The first asked respondents to choose which profession best described them. The majority of respondents were archaeologists. The second asked them in which industry they were mainly employed. The majority of respondents here identified themselves as government employees. Figures 1 and 2 below show the responses by percentage.

![Figure 1. Career by respondent.](image-url)
The comparison of career versus sector (Figure 3) shows some expected results. All cultural heritage managers are employed in the government sector as are a large number of archaeologists. Museum staff are evenly divided between archaeology, conservation and responses falling into the “other” category. None of the respondents were chemists, biologists or oceanographers. This does not mean that these professions are not involved in preservation of underwater cultural heritage. It is possible that they were either among those who did not participate or they responded, but did not view those categories as their primary profession. As previously mentioned, this may make the sample less representative of the population than expected. Sector designations themselves were not without issue. Respondents could define themselves within more than one sector. For instance, in some countries, museum employees are also government employees. As with careers, respondents were asked which sector they viewed as their primary employer.
Assessing General Site Types

The first section of the questionnaire addressed the general conditions of sites regularly investigated by the sample population. The first question (A1), concentrating on types of sites, showed a full complement of sites are being investigated, with the two most prominent being shallow sites (those less than 10m/30ft) and mid-depth sites (those between 10m/30ft and 30m/100ft). How the sites were situated relative to their environment also proved extensive in range, with those partially buried and those in a constant state of flux being the modes (A2). Archaeological surveys and excavation were the types of investigation most prevalent, though more than half of respondents have also performed conservation surveys on sites (A3).

Visual inspection of materials and basic measurements, such as temperature, salinity and water pH were the most readily recorded information collected during conservation surveys (A4). Responses provided in the “Other” category include
wood identification, bacterial analysis and tests for biological degradation. While 49 respondents specified that they had done formal conservation surveys in question A3, the fact that 59 responses were collected for specific conservation survey data collection (A4) points to the reality of archaeological fieldwork. Formal conservation surveys may not be undertaken, but collection of some pertinent data may be collected as part of another activity.

Seventy-nine of the 81 respondents who specified they had undertaken excavations have participated in conventional excavation and retrieval followed by conservation of material remains (A5). Two-thirds have used in situ preservation, while over one-third has used in situ storage. Sixteen report having worked on sites in which the material remains were destroyed after excavation. As expected, the majority of materials excavated were wood/cellulose organics and ferrous metals, though all materials were well represented (A6).

Some respondents took advantage of the open-ended response area at the end of Part A to clarify and expand their answers. Many of them noted that it was difficult to generalise about sites as the methods of survey and excavation are decided upon in a site-specific manner. This was one of the limitations noted during the development of the survey, but was acknowledged as an acceptable risk. Comments made by respondents can be found in Appendix B. It should be noted that while due care has been taken to reproduce these comments faithfully, modifications have been made for anonymity, formatting and spelling. These comments will be explored more in the next chapter.

**Use of In Situ Preservation and Storage**

Eighty-three respondents answered the question “Have you or your organisation used in situ preservation or storage and how often is it employed on sites” (B1). Figure 4 shows that, of the respondents, 70 have previously used some form of in situ methods and techniques, ranging from once through to always. Thirteen respondents have never used any form of in situ preservation. In the follow up question (B2), of the 70 who have utilised in situ preservation and storage, almost all (66) stated they would continue to use these methods and techniques, while three would not (Figure 5).
For those who have never used *in situ* preservation or storage (B13), “site conditions” was given as the primary reason, followed closely by financial considerations and “Other” (Figure 6). Of the five reasons listed in the “Other”
category, four respondents cited excavation and recovery of all cultural remains. Lack of convincing research also featured prominently. As thirteen people answered this question and there are thirty-nine responses, each respondent had on average three reasons for not choosing to use *in situ* methods and techniques. Complex issues appear to be involved when making site management decisions.

![Figure 6. Reasons for never using *in situ* preservation (B13).](image)

Of the three respondents who have used *in situ* methods and techniques in the past but have chosen not to continue using them (B3), the graph shows that access to equipment and materials to carry out the necessary work and “Other” were two main reasons (Figure 7). This is slightly misleading as one of the responses in the “Other” category is that the respondent feels there is not enough research to support the idea, although with the caveat that the respondent feels this is primarily in regards to *in situ* storage rather than *in situ* preservation. This response could be considered to fit within the category of “Insufficient suitable research”. Again, government legislation was a factor for one of the three respondents.
For all those not currently using \textit{in situ} methods and techniques (B4 and B14), new supporting research and access to funds were the two main reasons given for reconsidering their decisions in the future (Figure 8). Also important were having access to professional personnel and better training. A number of other factors were raised under the “Other” category. One respondent would use \textit{in situ} preservation and storage provided there would continue to be the ability to learn from the site and it would not be used simply as a way to avoid the issues inherent in managing sites. Another would consider utilising \textit{in situ} methods as long as there remained the guaranteed ability for site access and that it could be done in a way that would prohibit looting. For one, site size, quantity of material and site location were factors for consideration.
As there was a possibility that career and sector demarcations impacted whether or not in situ preservation and storage was employed, the background questions were analysed alongside responses to use. The graph shows that a majority of archaeologists (66%) use in situ preservation and storage (Figure 9). A similar pattern is apparent in all other cases, though conservators and cultural heritage managers were more likely not to have used in situ methods. There are several possible reasons for this. In the case of cultural heritage managers, the prospect of government interference or indifference exists as does the lack of time and funding. The conservators, on the other hand, may be more likely to have assessed the sites and determined that in situ preservation was not appropriate. It is also possible that many conservators do not dive and are essentially laboratory-based, conducting active conservation on recovered artefacts. This may have affected the decisions they made.

Figure 8. Reasons given for reconsidering use of in situ methods in the future (B4 & B14).
A review of Figure 10 depicting career versus reasons for not using *in situ* preservation and storage shows that conservators did have a reason for not choosing to utilise *in situ* methods and techniques in certain instances. Materials that were too degraded were not deemed suitable. However, conservators were, as a whole, influenced by many of the same factors as archaeologists and cultural heritage managers, such as lack of personnel to carry out the procedures, permitting issues and inability to access required materials and equipments. While the graphs do not illustrate much in the way of correlations due to the small sample size not using *in situ* methods and techniques, it does show that decisions against the use of this form of preservation are influenced by a wide number of factors.
Figure 10. Career versus reasons for not using *in situ* methods.

As Table 1 demonstrates, running a number of tests for measures of associations shows little to no relationship between choice of career and decisions to use or not use *in situ* preservation and storage. Values that show strong correlation and are likely linked range between 0.700 and 1.000. Those that are most likely not linked lie between 0.000 and 0.300. The lambda shows no relationship at all when career is used as the dependent variable, indicating independence. Cramer’s V shows very weak relationship. Goodman and Kruskal, being more sensitive, was used to determine which of the previous was most accurate. Clearly, no relationship exists between career and attitudes towards the use of *in situ* preservation and storage. Decisions must derive from institutional or agency policies, availability of personnel and financial concerns. Quite possibly other influences that have not been taken into consideration in this questionnaire, such as previous education and personal experience, may also play a role.
Table 1. Measurements of association between career and use of *in situ* methods.

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<th>Measurement of Association</th>
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<td>Lambda</td>
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<tr>
<td>Symmetric</td>
<td>0.032</td>
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<tr>
<td>Career Dependent</td>
<td>0.000</td>
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<tr>
<td>B1 Dependent</td>
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<tr>
<td>Cramer’s V</td>
<td></td>
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<tr>
<td>Goodman and Kruskal tau</td>
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<tr>
<td>Career Dependent</td>
<td>0.047</td>
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<tr>
<td>B1 Dependent</td>
<td>0.047</td>
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<tr>
<td>Uncertainty Coefficient</td>
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<tr>
<td>Symmetric</td>
<td>0.078</td>
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<tr>
<td>Career Dependent</td>
<td>0.095</td>
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<tr>
<td>B1 Dependent</td>
<td>0.067</td>
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In terms of approaching which *in situ* methods and techniques would be used (B5), the large majority of respondents noted that their choice would not necessarily be the same as approaches previously taken. Reasons for this (B6) centred around the development of site-specific programmes, access to money and the availability of new research and techniques. This clearly follows the pattern of thought put forth by many in Part A concerning the difficulties in generalising about sites.

The responses to the question B7 show that reburial and sandbagging are the primary methods of *in situ* preservation being used by practitioners. Shade cloth and geotextiles have been used by a third of respondents, as has the technique of sediment drops. While sacrificial anodes were overlooked as a response in the development of the questionnaire, perhaps an unforgivable oversight, it did appear as a response to the “Other” category. Also noted was the building of underwater containers of sorts, either for the deposition of sediment as in road crash barriers or as open water storage boxes in anoxic waters.

*In situ* storage has been used by practitioners in a number of circumstances, such as on sites threatened by development or where the environment was seen as detrimental to the ongoing survival of material remains. One respondent noted that storage was used to facilitate research access to recovered artefacts; another expanded this thought by adding that locating artefacts was made easier by *in situ* storage. Five respondents mentioned lack of project funding. Three also mentioned that storage was used to inhibit looting by divers. Responses showed
the majority of reburial in *in situ* storage instances was in an environment similar to the original site (B9). Most respondents who reburied materials in a different environment failed to address the follow-up question posed. Of those that did, one cited the best compromise available at the time, designed to keep the timbers wet, another pointed to the decision to use an area that was less prone to scouring and a third noted that the move from beneath the sediment into open water occurred in a specific environment in which anoxic levels existed above and below the sediment.

While the majority of respondents did not use packaging materials in their reburial schemes (B10), those that did used a variety of materials, the most popular of which were tagging items. In one case, net line cradles were constructed to hold amphorae. Twelve of the 24 respondents used some type of marker. Being able to re-identify artefacts is clearly a priority in these instances. Where packaging materials were not used, the majority of respondents believed they were unnecessary. Time constraints also played a role in the decision to forego packaging.

A variety of comments were made in the open-ended section at the conclusion of Part B. Some respondents used the space to clarify their stance. Others expanded answers given by providing more particulars about sites worked on. Responses can be found in Appendix B and will be further analysed in the following chapter.

**Decisions Regarding Monitoring**

Three-quarters of the 81 respondents answered question C1 concerning the monitoring of sites in the affirmative. Of those 62 respondents, only 13 report formal monitoring schedules exist (C2). Types of schedules include purposively timed site visits and on-site dataloggers that collect continually over the course of a year. Even those who do maintain formal schedules, however, often have difficulties maintaining those schedules. Four respondents remarked that while they make every attempt to maintain the set schedules, planned excursions are often interrupted by weather, availability of personnel, funding and politics. Two respondents noted that over the course of their careers, they have worked for institutions that have either not monitored at all or only monitor certain sites.
Reasons for monitoring sites were varied. Most included a combination of ensuring the integrity of the site, updating existing site plans and monitoring *in situ* preservation. Other reasons provided focused on cultural heritage management of public sites by ensuring safe access for the diving community, clean interpretive materials and minimal occurrence of looting. One respondent was concerned about whether *in situ* methods were able to preserve the integrity of the site.

For all respondents, visual means of monitoring such as on-site note-taking, photography and videography were the most prevalent form of monitoring (C4). Although not asked in the questionnaire, a likely reason for this is that it remains a relatively cost-effective procedure that can rely on volunteers, pencils and paper at its minimum. Almost half of respondents use other methods, such as sampling and analysis of materials and sediment or corrosion measurements. Cameras and video equipment remained the most chosen pieces of equipment (C5). Other responses included total station; multibeam and side scan sonar; dataloggers and sediment corers.

Two-thirds of respondents relied on single use equipment brought to the site each time for collecting measurements (C6). Of the remaining third, only five had permanent monitoring equipment set up on site while 17 collected samples and analysed them *ex situ*. Twenty-two respondents commented on whether or not they would make changes to their monitoring process and what those changes would be (C7). Four believed that their monitoring programmes were adequate. Four would like to use on-site equipment, while two would employ advanced technology or newer equipment on site. One respondent had begun to incorporate an on-site corrosion study into the monitoring scheme. Seven references were made to being constrained by available funds. Four cited personnel as the deciding factor. Volunteers were considered to be integral to site monitoring, with one respondent looking to involve more avocational groups in data collection.
Time constraints, lack of availability of professional personnel and the difficulties of funding were the primary reasons chosen by those who do not monitor sites (Figure 11). Other important issues are the internal policies of the organisation and difficulties accessing equipment and materials. Two respondents reported a difficulty that could be prevalent in consulting projects: the inability to access the site once the project is deemed complete. This could have serious ramifications for sites that are not in the public domain. There remains the chance that for-profit corporations will manage to circumvent government legislation and policy, especially when practitioners already report that lack of funds and personnel currently hinder site management.
Factors provided that would cause respondents to reconsider their stance on monitoring paralleled those reasons given for not monitoring (Figure 12). Increased funding and available time were the main considerations. One respondent noted the inherent difficulty of attempting to coerce clients to carry out continued monitoring. While recommendations may be made in the final report, once the contract of employment comes to a close, little can be done in the way of ensuring recommendations are carried out.

As with the use of *in situ* preservation and storage, measures of association were run against career choice to determine if it was an influencing factor on use of monitoring (Table 2). This pattern is similar to that seen in Table 1 where career was not seen to influence use of *in situ* methods. The lambda indicates that the two variables are completely independent of one another. Cramer’s shows only a very minimal relationship. The Goodman and Kruskal tau confirms that neither variable is dependent on the other. Again, a more complex relationship between a number of variables such as those explored in question C9 exists in terms of decisions about monitoring.
Table 2. Measures of association between career choice and use of monitoring.

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<th>Measurement of Association</th>
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<td>Symmetric 0.000</td>
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<td></td>
<td>Career Dependent 0.000</td>
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<td>B1 Dependent 0.000</td>
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<td>Cramer’s V</td>
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<td>Goodman and Kruskal tau</td>
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<td>Uncertainty Coefficient</td>
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<tr>
<td></td>
<td>Career Dependent 0.021</td>
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<td>B1 Dependent 0.029</td>
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The open-ended question following Part C was also well utilised. Again, many chose to clarify or expand their answers. Lack of funding and personnel remained a theme throughout. These comments will feature more prominently in the discussion of emerging issues in Chapter 5.

Conclusion

The analysis of this questionnaire shows interesting results. All practitioners, bar one, believe that *in situ* methods and techniques can be a useful tool for protecting underwater cultural heritage. Of the seventeen who currently refrain from using *in situ* preservation and storage, sixteen would reconsider their choice given a number of circumstances, including new research that would support the benefits. Overwhelmingly, practitioners feel the choice of preservation method must be site specific and that monitoring remains an important part of site management plans. Lack of funding, professional personnel and volunteers, not surprisingly, are the issues most affecting how sites are investigated, preserved and managed. The open-ended questions have shown that there are a variety of different understandings and approaches to *in situ* preservation and storage that will need to be addressed in order to create a cohesive strategy to approach the practice of *in situ* methods and techniques.
Chapter 5: Examining Attitudes and Issues

The previous chapter presented a quantitative analysis of the administered questionnaire. The comments made in the open-ended sections of the questionnaire are perhaps more telling than the numbers of practitioners using *in situ* preservation and storage or how many used which method. In this section, the issues facing advocates and opponents alike come to the fore and highlight the practical, academic and emotional reasoning that is currently informing practitioners’ attitudes towards the practice of *in situ* preservation and storage. Demonstrating the current attitudes will allow practitioners to engage in meaningful dialogue. This dialogue will help steer research towards not only developing improved methods from the scientific point of view, but also understanding the ethical issues of preserving submerged cultural heritage, implementing sustainable management programmes and continuing to gather the types of data integral to archaeological investigations.

When reviewing the statements made by practitioners, five main themes emerge. The lack of convincing research into methods as well as a shortfall of quantitative data demonstrating the success of *in situ* preservation and storage remains a foremost issue. Another identified issue involves the ease with which some agencies approach *in situ* preservation and storage, leaving cultural resource managers to overcome the “out of sight, out of mind” stigma. The idea that *in situ* preservation and storage is meant to curtail any and all excavation and the implications that mentality has on the discipline of maritime archaeology concerns archaeologists in particular, while the idea that *in situ* preservation and storage is the “best” form of conservation for underwater cultural heritage concerns a broad range of practitioners. The final theme that emerges is how *in situ* methods and techniques impact access in terms of researchers and the general public.

Each issue is an important aspect in considering the options available to practitioners for choosing to use or not use *in situ* methods. Obviously, different understandings exist about *in situ* preservation and storage and these need to be addressed. Below, issues identified from the questionnaire will be approached separately in terms of the effects on practitioners and what dialogue and research is necessary to create a cohesive approach that is acceptable to all practitioners.
involved. The previously reviewed literature will be examined alongside practitioners’ responses in order to understand its influences on practitioner’s attitudes and beliefs about in situ methods.

**Continuing Research**

It is imperative that the techniques and the science on which in situ preservation and storage strategies are based continue to be investigated and published. This is highlighted in the questionnaire, with thirty-five percent of respondents choosing to not use in situ preservation and storage due to a perceived lack of supporting research. Two responses to open-ended sections take this idea of insufficient research one step further. The first commented that the science behind in situ techniques remains poorly developed (Appendix B, p. 118, no. 7) while the second queries how and where investigations take place (Appendix B, p. 120, no. 30).

Chapter Three clearly demonstrates that while a small percentage of practitioners believe the science to be underdeveloped, this is not the case. The physical, chemical and biological mechanisms associated with preservation and decay have been and continue to be explored. The research is well structured, following accepted tenets of scientific research. Certainly, some scholarly disagreement about methods and results exists, as noted in the discussion in Helms et al. (2004), but this is to be expected and indeed encouraged in rigorous academic and scientific discourse. Researchers themselves remain acutely aware that there are still many factors that require further investigation. RAAR, in each of its sub-projects, calls for continued sampling and analysis in order to assess the long-term effects of reburial on archaeological and packaging materials (Björndal & Nilsson 2007; Bohm et al. 2007; Gregory 2007; Nyström Godfrey et al. 2007; Peacock 2007; Richards & MacLeod 2007).

p. 119; 2004, p. 79) and her team continue to experiment with new and improved techniques to isolate and identify erosion bacteria in waterlogged wood. This is just one example from the literature review that reveals continuing investigation into the questions currently plaguing researchers.

It is likely that where such results are published plays a key role in the perception that scientific research into the processes of in situ preservation and storage is underdeveloped. Due to the nature of this research, it tends to appear in scientific journals such as *International Biodeterioration and Biodegradation* or as a result of conference publications by specialist groups such as the conservation committees formed by the International Council on Monuments and Sites (ICOM). Even should practitioners be aware of these publications, they may be difficult for those outside the discipline to understand, affecting knowledge and access.

As to whether or not experimentation with techniques should be carried out on archaeological sites (Appendix B, p. 120, no. 30), field projects such as RAAR are important to the study of in situ preservation and storage, especially when coupled with laboratory experiments. Important information has also been gathered during projects completed on archaeological sites. Comments provided in Part A of the questionnaire stress the significance of site-specific choices when investigating underwater cultural heritage. Data collected during BACPOLES and MoSS allowed researchers to explore how different materials, environments and processes on different sites affect preservation (Manders 2004b, p. 279). While the respondent correctly identifies the need to devise off-site controlled experiments in order to isolate important variables, it is neither practical nor feasible to halt experimentation on archaeological sites.

The lack of funds and personnel available to properly manage sites, including the use of in situ preservation and storage in many instances, also has ramifications in terms of laboratory or field experimentation. Both of these problems seriously limit the number of experiments that can be undertaken. Not exploring these ideas on archaeological sites may be detrimental in the end, as at-risk sites may be left to deteriorate further in the interim. Even though it served as only a temporary fix, sandbagging William Salthouse allowed cultural resource managers to investigate
a more permanent way to stabilise the wreck (Harvey 1996, p. 1; Hosty 1988, p. 13). The experimental use of artificial seagrass on the site provided, for the most part, protection in the medium term. Had the decision been made to not test the seagrass theory, the site may well have been destroyed before an acceptable off-site experiment produced the necessary supporting data.

On the wreck of James Matthews, sandbags again have provided adequate, though understandably temporary, protection without having a detrimental effect (Godfrey et al. 2005, p. 64; Winton & Richards 2005, p. 79). The project has ably combined temporary measures with off-site experimentation of plastic “crash barriers”. The off-site experiment has yielded important information (Winton & Richards 2005, pp. 86-87), but in reality, the use of a larger matrix around James Matthews may have unforeseen difficulties which have the potential to adversely affect preservation. There remains a certain amount of inherent risk regardless of how much off-site experimentation is completed. Experimentation on archaeological sites, as long as it is carried out in an ethical and logical fashion, has the ability to provide new data and perfect methodology while providing real-time preservation.

Results from phase one of the RAAR project underscores the need for continued research (Bergstrand & Nyström Godfrey 2007, pp. 7-8). Previous conclusions such as the fifty centimetre anoxic burial depth have been shown to be less reliable than originally believed (Bergstrand & Nyström Godfrey 2007, p. 8). Preliminary results also show that reburial of certain materials may be problematic and that reburial may be more material specific than first assumed as, for example, with glass and low-fired earthenware (Bohm et al. 2007, pp. 25-26).

More research is also required to fully characterise the nature of the anoxic burial environment and the microbes present. Not only is it not yet known which bacterial species cause biodeterioration of organics (Björdal & Nilsson 2008, p. 869), it is also not understood how the use of various elements such as sulphur and iron by these organisms will affect long-term preservation of reburied materials (Huisman et al. 2008, p. 33). Other parameters, such as pH and redox potential also need to be better understood through sampling and monitoring the environments on site (Caple 1998, p. 122). New technologies will inevitably aid
researchers in collecting this data. While Gregory (Gregory 2007, p. 25) believes that at present dataloggers can be unreliable and expensive, he feels advances in their design may make them more relevant for practitioners in the near future.

The review of the literature carried out in this thesis points to the steady and continued accumulation of quantifiable data supporting in situ preservation and storage. While by no means complete, the level and quality of data to date points to the usefulness of in situ techniques within underwater cultural resource management. Practitioners in general accept this to be true. Nonetheless, exploring long-term effects and developing cost-efficient techniques should remain at the forefront of investigations into in situ preservation and storage.

Maintaining Active Management

Practitioners also expressed their concern that while in situ preservation and storage provided cost- and resource-effective means of protection, it may be manipulated by those who fund management programmes, leaving sites only marginally protected. Three respondents spoke of the fear that government management agencies prefer in situ management programmes as they appear to be a “do-nothing” approach that leaves the cultural heritage both out of sight and out of mind (Appendix B, p. 118-120, nos. 7, 10 & 26). Another notes that when ‘you can’t tell the difference between in-situ [sic] preservation and neglect then its [sic] actually just neglect’ (Appendix B, p. 119, no. 20). Some practitioners find it disconcerting that the potential may exist for bureaucrats intent on protecting the financial bottom line to adopt the “do-nothing” attitude and label it in situ preservation. It is imperative that a clear and concise definition of in situ preservation and storage exists to counter this misconception. In situ preservation must be viewed as an active tool, incorporating monitoring and pro-active initiatives to slow deterioration.

Some agencies have used in situ preservation and storage to their advantage. Davide (2002, p. 83) explores the Italian approach to underwater resource management. While the primary focus is on public accessibility, the use of in situ methods has allowed the Italian government to actively manage sites for which they are responsible. Florida is also dedicated to preserving submerged heritage for public access and has used sacrificial anodes and conservation surveys to help
maintain their system of underwater parks and trails (D. Scott-Ireton 2008, pers. comm., 22 September). What is interesting in this small sample is that areas developed for or frequented by the public are likely to be preserved in a more active fashion than those less accessible.

What is less obvious is whether sites outside the public sphere receive the same level of treatment. Possibly those sites which have a champion or have a significance that stirs public opinion, such as the Duart Point wreck (Gregory 1995, p. 61; MacLeod 1995, p. 53; Martin 1995, p. 15) or Pandora (Gesner 1993, p. 7; Guthrie et al. 1994, p. 19), may be more likely to receive treatment than those without. While it is indeed difficult to afford every site the same level of investigation and protection, it may be easier to not become involved if in situ preservation and storage becomes entwined with the “do-nothing” attitude. Not all agencies approach in situ methods and techniques as a cost-efficient management tool. One respondent reported their agency viewed in situ as too expensive in terms of time commitments (Appendix B, p. 118, no. 7).

Most practitioners also viewed monitoring as an important yet often underdeveloped element of both in situ preservation and storage and site management. Access to funding and personnel was once again a reason for failure to monitor, yet it was understood to be essential to the management plan (Appendix B, p. 132-33) But again, those funding work appear to be less than convinced of its necessity. ‘[W]e are still in the middle of a political fight to get enough funding to be able to execute an overall monitoring scheme’ reports one respondent (Appendix B, p. 133, no. 17). Another states department managers need to be convinced of the necessity. In situ preservation and storage may run the risk of being misused by those who could come to view it as an easy way to subvert responsibility. These responses point to a need to educate policy makers and management above the level of practitioners.

One method that appears regularly in both the literature (Beasley 1994, p. 150; Hall 1994, p. 157) and questionnaire responses is the use of avocationals where funding and personnel are limited. One respondent noted that management plans for several World War II vehicles included the training of locals as site stewards and engaging with dive operators as these groups represent stakeholders in the
resource (Appendix B, p. 118, no. 4). While this is one way of circumventing the lack of funding and personnel, it does nothing to hold agencies accountable for the resources under their control. Involving the public in the management of their heritage is certainly a key to managing sites as well as lobbying agencies. What else beyond funding can be done to mobilise agencies is yet to be determined.

**Procuring Knowledge**

*In situ* preservation and storage has unfortunately acquired a negative persona in some circles. This is a result of two different groups. One group is comprised of the treasure hunters and salvors, who wish to exploit the resource for monetary gain. They manipulate public opinion by claiming *in situ* techniques are unsuccessful and that they are in fact protecting underwater cultural heritage by retrieving it for the public (Grenier 2006, p. x; Hall 2007, p. 2). One individual mentioned the intentional use of deceptive information by treasure hunting and salvage groups in order to convince the courts and the public that *in situ* techniques do not protect submerged cultural heritage.

A small number of archaeologists in the questionnaire, on the other hand, caution against its use by pointing out that it is used to prevent excavation and therefore the collecting of archaeological knowledge. Comments made in this vein included ‘[w]ithout excavation we learn nothing, either archaeological, historical or technological. Leaving it to the future is a cop out’ (Appendix B, p. 121, no. 34), though in this case, the respondent did concede that *in situ* preservation and storage does have its place within maritime archaeology. Another felt that the development of maritime archaeology could be hindered by the lack of excavations in recent years, citing ‘a continued regression in training and technology which are a direct consequence of the continued (and increasing) reluctance to proactively and intrusively investigate sites’ (Appendix B, p. 119, no. 17). Another respondent believed that money spent on poorly understood *in situ* techniques was money not spent on collecting data that can ‘justify the importance of maritime archaeology’ (Appendix B, p. 118, no. 7).

Interestingly, the literature does not support these allegations. It was difficult to locate many articles that developed the idea that preservation of underwater cultural heritage was curtailing excavation. For example, Sutherland (2002, p.
feels that a misunderstanding of marine artefact conservation, especially the emphasis on the expense involved, means that sites that could be contributing knowledge are not being excavated. She then ties this into the ease with which these same sites then become victims of treasure hunters and salvors. Browsing the contents of the *International Journal of Nautical Archaeology* certainly gives the impression that excavation is continuing to occur. Is this then an issue only in the minds of a few, or is it far more prevalent? If indeed it is being voiced in the back room at conferences with growing emphasis, practitioners need to bring it to the forefront of discussion in order that it be addressed.

Projects such as RAAR are also beginning to show that there is the possibility of utilising *in situ* storage methods in order to continue exploring sites through excavation. The prospect of creating storage areas that will allow for the retrieval of material for research holds for some the answer to maintaining a balance between preserving submerged cultural heritage and continuing to collect knowledge from it. Certainly, a framework will need to be created that takes into account risks to the cultural material, as well as risks to the environment and ecology of the created storage area (A. Viduka 2008, pers. comm., April). Also important in this debate will be public access factors.

The literature does, however, provide ample examples of articles about the ethics of treasure hunting and commercial salvage, although these seem to be written from the archaeological perspective. It has been noted that, unlike other archaeological sub-disciplines, maritime archaeology appears obsessed with the illicit procurement of artefacts (Maarleveld & Auer 2008, p. 69). Within the structure of the questionnaire, it was impossible to distinguish those archaeologists working for salvage groups on the basis of their answers. This is contrary to the statement that ‘[t]here is wide-spread confusion among members of the professional community, as well as among the public regarding in-situ [sic] preservation and storage. This is intentional among some segments of the salvage/treasure-hunting groups to justify the ‘marine peril’ argument that furthers their chances of success in obtaining salvage awards’ (Appendix B, p. 120, no. 30). In fact, the majority of archaeologists cited the lack of funds and other issues, such as complete excavation of sites, as reasons for not using *in situ* techniques (see Figure 10, Chapter 4).
The above examples clearly demonstrate one of the problems inherent with self-administered questionnaires. There is no way to determine whether or not respondents are providing an accurate picture of reality (Foddy 1993, p. 3). With differences of opinions existing about who qualifies as an archaeologist or what constitutes a treasure hunter, it is difficult in an anonymous questionnaire such as this one to clearly determine whether or not treasure hunters and the archaeologists associated with their work are attempting to subvert understandings of in situ preservation and storage. Neither can it be determined whether uses of in situ techniques are causing a decrease in excavations. New emphasis on underwater museums and trails for the public may play a part in limiting excavation as may the development of more sophisticated research designs. Perhaps a project utilising an interview-style survey would be able to collect in-depth information on this topic. Round table discussions at conferences would also be beneficial.

**In Situ as a Tool**

‘In situ [sic] preservation/reburial is not a universal panacea for maritime archaeology. It is a real tool in the methodology of the profession that can be used in conjunction with a risk management framework’ (Appendix B, p. 119, no. 16). As this respondent states, there is a dichotomy within maritime archaeology as to how in situ preservation and storage is used and understood. The UNESCO Convention (United Nations Educational, Scientific and Cultural Organization 2001) and the ICOMOS Charter (International Council on Monuments and Sites 1996) state that in situ preservation should be considered as the first option. However, as many of the respondents stated at various points throughout the survey, it remains but one tool to be considered and its use should depend upon a number of considerations. This includes the significance of the site, the environment of the site, access to necessary and on-going funding and the development of a clear and well-constructed research plan.

As Green (2003, p. 371) states, ‘[a] pragmatic approach to CRM is a mix of in situ preservation and archaeological excavation.’ In his 2003 text *Maritime archaeology: a technical handbook*, Green dedicates a chapter to defining cultural resource management. While not going into any specifics about the techniques of
*in situ* preservation and storage, what Green does do is provide an in-depth and concise account of how to create a cultural resource management plan (Green 2003, pp. 370-371). By creating a site-specific plan that takes into account all the variables, underwater cultural heritage can be protected in a way that is “best” for each site. If the “best” protection for the site is to be found in a full excavation with retrieval, conservation and display of all cultural materials, then the classic tenets of archaeology can be justified.

Benchmarking these parameters in a formal way may help convince agencies to become more active in managing sites. Six respondents expressed a desire to be able to monitor sites more frequently and in a scheduled fashion (Appendix B, p. 128-129, nos. 8, 10, 12, 14, 17 & 22). Another noted that as *in situ* preservation and storage becomes more prevalent, a ‘standardised framework for collection management *in situ* will need to be established’ (Appendix B, p. 132, no. 10). Bernier (2006, p. 64) concurs, noting that such guidelines will need to provide clear direction and allow for consistency without being either too lax or too constrictive for cultural resource managers. This will allow managers to make decisions in the best interests of the site. As one respondent stated, options must exist that can allow for “pure research” or mitigate a sensitive and threatened site (Appendix B, p. 120, no. 17).

Managing cultural heritage often relies heavily on the amount of funding available. On the surface, *in situ* preservation and storage can appear to be the cost-efficient choice as compared to excavation, conservation and storage. However, as with most maritime archaeological activities, there is the potential for *in situ* preservation and storage to be an expensive endeavour. As protecting William Salthouse has shown, *in situ* methods and techniques can be costly (Harvey 1996, p. 1).

Equipment, such as dataloggers and electrodes, can be expensive. Maintaining and monitoring a site over a number of years can be costly in terms of time and personnel. It is essential that the best management decision is made, whether that is *in situ* preservation or excavation. ‘Financial restrictions aside, we can still study and enjoy the resources, left in situ [sic], for many years into the future.
Gaining knowledge from the sites is one of the most important aspects of leaving sites in situ [sic]’ (Appendix B, p. 119, no.21).

**Including the Public**

The final issue focuses on how *in situ* preservation and storage can be used or adapted for the public’s best interests. Access remains an important topic for cultural resource managers. *In situ* preservation and storage could be seen to keep underwater cultural heritage out of the public’s domain, as noted by one respondent (Appendix B, p. 119). Certainly, leaving cultural heritage underwater does limit the number of individuals who are able to interact with a particular site. However, rarely does a museum have its entire collection on display and certain terrestrial sites remain closed to the public due to their fragility. The cave at Lascaux, for example, has been closed to the public since 1963, when it was noted that the paintings were being damaged as a result of environmental changes caused by visitation (Delluc & Delluc 1984, p. 194). Submerged cultural heritage must be treated with the same consideration. Fragile sites need a higher level of protection.

This is not to say that submerged cultural heritage should be made off-limits to the public. Indeed, as noted by many respondents, the public can have an important impact on how sites are managed. Seven respondents would be more likely to use *in situ* techniques or monitor sites if more volunteers were available. Well-trained volunteers could be utilised in a number of ways, including collecting data and monitoring sites protected by *in situ* methods. Volunteers, however, are those members of the public who are interested in actively working to protect their cultural heritage. Many members of the public simply want to enjoy cultural heritage through historic trails and museums. Using *in situ* preservation and storage along side other management tools such as monitoring to interact with the public was mentioned by four respondents, by way of underwater parks, trails and museums.

*In situ* techniques have allowed wrecks, such as *William Salthouse*, *Xantho* and those in Florida’s underwater heritage preserves, to be enjoyed by the public. Of course, this method has its drawbacks as noted by respondents. With looting by salvors and recreational divers still an issue, a small minority of practitioners feel
in situ preservation leaves wrecks vulnerable. Archaeologists in Florida did consider this and as a result, replaced some artefacts that were possible targets for looting with replicas (D. Scott-Ireton 2008, pers. comm., 22 September).

Ultimately, the public will not have access to underwater heritage if it is not preserved in one form or another. With space in museums at a premium, it has become a challenge for cultural resource managers to balance the on-going preservation of underwater sites with public access. If utilised well, in situ preservation affords cultural resource managers a way to achieve both. As one respondent noted, technology is advancing quickly and the ability to create real-time underwater museums is fast becoming a possibility (Appendix B, p. 121, no. 32). This has been tried with some success in Italy (Davidde 2002, p. 83). Florida recently unveiled its new website Museums in the Sea (Division of Historical Resources, Bureau of Archaeological Research 2007) to showcase its underwater archaeological preserves. Videos and images on the site allow the non-diving public to explore underwater cultural heritage they otherwise could not access. While these videos, etc. are not real-time at present it will be possible in the future.

**Continuing the Discussion**

Perhaps the biggest challenge to this research will be creating and maintaining the interdisciplinary discussion necessary to ensure that ideas and findings are disseminated to all practitioners. The interdisciplinary nature of the investigations makes it challenging in terms of locating academic materials. Articles are not only found in archaeological and cultural resource management journals such as *The International Journal of Nautical Archaeology* and the *Journal of Cultural Heritage* but they are also found in a number of scientific journals, such as *International Biodegradation and Biodeterioration* and *Marine Chemistry*. Some, like the *Journal of Archaeological Science*, attempt to bridge the gap by looking at the scientific rather than the humanistic advances of archaeology. Conference publications, such as those by the ICOM conservation work groups, remain an important source of information, but are not as easily accessed as journals, which tend to be accessible online.
Archaeologists and cultural resource managers are not typically trained in conservation or material sciences. Nor are conservators and material scientists typically trained in archaeology or cultural resource management. It is important to create ways in which new methods and findings can be communicated between groups (McCarthy 1987, p. 9). The joint conference held by the Australasian Institute for Maritime Archaeology and the Australian Society for Historical Archaeology in September of 2008 is an example of the venues in which such discourse can occur. A session chaired by Vicki Richards of the Western Australian Museum focused on in situ preservation and featured a wide variety of practitioners in archaeology, cultural resource management, conservation and materials science.

University programmes also need to reflect emerging in situ practices. Traditionally, conservation topics in archaeology have focussed on conventional laboratory treatment of recovered artefacts. Educating those who are training to become practitioners is an important aspect of changing attitudes towards in situ preservation and storage. Developing courses that demonstrate the values and methods of in situ techniques should be considered by course convenors.

Recently, a graduate course held at Flinders University, Adelaide, South Australia, provided maritime archaeology students with both scientific background and practical experience in using in situ preservation as a tool.

Other successes have been projects, such as BACPOLES and MoSS, which featured similar multidisciplinary groups. Diverse opinions exist about the value and effectiveness of in situ preservation and storage. While only one respondent stated that nothing would change their mind about its use, it is clear that no one solution will satisfy practitioners. More research into the chemical, mechanical and environmental issues ranked first and foremost as a reason to reconsider in situ as an archaeological tool. But it is important to note that this must be considered alongside other concerns such as funding, personnel, training and protection from looting.

As projects such as RAAR continue to provide new data, certain ideas about in situ methods and storage will change. Some, however, will continue to be debated, such as access for the public and best practices for cultural heritage
management in terms of site significance and archaeological research potential. The questionnaire demonstrates, when viewed alongside the literature, that practitioners need to engage in active and ongoing discussions about *in situ* preservation and storage, not only among themselves, but with policy makers and the public.
Chapter 6: Conclusion

This thesis aimed to explore views and beliefs about in situ preservation and storage held by the interdisciplinary community of practitioners active in its development and deployment. This conclusion will present a summary of the information gathered in light of the questions asked in Chapter One. The implications these finds may have on future work will also be discussed.

Bodies of Literature

Archaeological materials are discovered, often in excellent condition, from waterlogged sites. Ultimately, these items require some form of preservation, regardless of whether or not they are recovered. In situ preservation and storage is becoming an accepted method for protecting underwater cultural heritage for many in the fields of archaeology, conservation and cultural heritage management.

This thesis demonstrates that there is an active interdisciplinary community investigating numerous aspects of in situ preservation. Experiments and projects have been undertaken globally for close to four decades. In truth, some early in situ projects were neither well-planned nor monitored, such as those in Stockholm, Sweden (Bergstrand & Nyström Godfrey 2007, p. 15). Others, such as the reburials at Red Bay, Canada (Grenier, Stevens & Bernier 2007), marked the beginning of a course of experiments investigating chemical, physical and biological processes as they pertain to underwater cultural heritage. Since the early 1980s, the body of research has grown considerably.

Laboratory and off-site fieldwork have provided new data about a number of different techniques and mechanisms. While investigations into the identification of anoxic cellulose and lignin degrading bacteria may not have produced full results to date (Helms 2005; Helms et al. 2004), experiments into culturing anoxic bacteria in archaeological work continue. The work done on identifying the microscopic patterns left by erosion bacteria have allowed wood scientists to determine what type of wood is most prone to degradation and at what depths degradation can generally be expected to occur (Björdal & Nilsson 2008; Björdal, Daniel & Nilsson 2000; Nilsson 1999).
The instigation of a long-term reburial study in Marstrand harbour has, in its first phase, provided interesting preliminary data about how different materials react with the burial site (Bergstrand & Nyström Godfrey 2007). RAAR is also investigating the correlation between depth and decay as well as experimenting with new equipment for monitoring environmental and chemical parameters. Should the necessary funding be secured for the next stages, RAAR stands to produce important results that will be able to either demonstrate or negate the effectiveness of in situ storage in its particular environment, providing a template for other studies elsewhere in the world.

Reburial is far from the only technique investigated. Sandbags were used on William Salthouse (Harvey 1996) and James Matthews (Godfrey et al. 2005) as a means of both covering the site and providing structural stability to ships’ timbers. While these projects eventually demonstrated that sandbags did not afford the protection expected or desired, William Salthouse, in particular, illustrated how temporary measures can aid in preserving cultural heritage in the short-term (Harvey 1996). Protective barriers such as geotextiles and artificial seagrass have also been shown to be successful through application on site (Harvey 1996; Manders 2006b; Pournou, Jones & Moss 1999).

Sacrificial anodes have also proven to be successful in protecting metal vessels. The use of anodes on a number of Australian wrecks has shown that active corrosion can be slowed (MacLeod 1998). Recent work by members of the Western Australian Museum has focused on understanding the complex set of interactions between modern metal wrecks and the marine environment (MacLeod et al. 2005). While the wrecks investigated were artificial reefs for the enjoyment of the diving community, the results have implications for the in situ protection of historical metal vessels. Research in this area will become increasingly important as ships from the mid-twentieth century begin to be viewed as archaeologically significant.

One of the issues encountered with the literature review was the size of the body of literature. Those projects believed to be the most significant in terms of results and impact on practitioners were explored. Unfortunately, many were left out, particularly those in the chemical, physical, biological and environmental
sciences. A 2007 article by Atkinson, Jolley and Simpson (2007) explores how pH, dissolved oxygen, salinity and sediment disturbance can cause metal release and sequestration in contaminated sediments. This directly ties in with anoxic bacteria that feed on sulphur, iron and manganese, which affect the preservation of buried organics. This one example points to how the varied background of in situ preservation may prove challenging to the dissemination of information.

A review of the literature, archaeological, chemical, biological and physical, highlights a rich and growing opus. Without doubt, some of the investigations into in situ preservation and storage have been less formal than others. This may be due to the immediacy of the archaeologist and cultural resource manager to stabilise sites and prevent any further deterioration. As careful as archaeology is to preserve the tenets of general scientific principles, it must remain unencumbered enough to deal with the unexpected that occurs in survey, excavation and preservation. However, the multidisciplinary flavour of the research points to the development of a well-rounded body of literature.

**Questionnaires and Practitioners**

Through the use of a questionnaire, this thesis set out to determine which practitioners were using in situ techniques and what the prevailing attitudes were towards the techniques available. Eighty-nine individuals representing 12 countries and a number of disciplines answered the questionnaire over a two-month period. The majority of respondents were archaeologists. In terms of employment sector, most were from within government. In terms of practitioner population, this may not be fully representative. As previously noted, in situ preservation is multidisciplinary in nature. The interpretation of results may have benefitted from the inclusion of more individuals practising in the chemical, physical and biological sciences.

The results of the questionnaire brought to light some interesting and unexpected issues. Practitioners on the whole were using in situ methods. Only 13 responded that they had never used in situ preservation or storage. Most of those cited site conditions and financial considerations as reasons for their choice. Three noted that they were able to excavate and conserve all cultural material. A second group of three respondents said that while they had used in situ techniques previously,
they would not continue to do so. In this case, lack of equipment and insufficient professional personnel were cited most often. Even though lack of research was cited as a reason for not choosing to utilise the method, it was not in overwhelming numbers. Most practitioners had more than one reason for using other methods. While it is clear that at present practitioners are not completely discounting in situ preservation and storage, they are not yet fully endorsing it.

The questionnaire also showed that respondents are both aware of and utilising a wide range of in situ methods. Backfilling and sandbags were the primary forms used, though other forms of reburial as well as sacrificial anodes, shade cloth and artificial seagrass were used. In situ storage was used for several reasons, including environmental and developmental threats, commercial interests and protection from recreational divers.

One of the queries set forth at the beginning of this thesis was to answer why practitioners chose to use a particular in situ method. In an obvious oversight, this question was never included in the questionnaire. This is unfortunate as the answers provided would have been able to add insight to practitioners’ attitudes. Based on other answers in the questionnaire, a possible hypothesis would include funding, site conditions and availability of personnel. As this questionnaire has shown, however, practitioners’ attitudes are complex and without having posed the question, any hypothesis would be little more than guesswork.

The clearest message from this questionnaire was that most practitioners see merit in in situ preservation and storage. The caveat is that it is not used as a blanket policy. The best form of cultural resource management is to consider the whole arsenal of tools available, to assess each site on an individual basis and to formulate a site-specific management plan that includes contemplating the funding, personnel, equipment and knowledge base available. Perhaps key to this is the development of open discussion by all practitioners and the continuance of projects similar to BACPOLES and MoSS, which allow experts from diverse areas to collaborate.
Into the Future

This study’s significance lies primarily in its use of a questionnaire to assess current understandings of a subject that stands to greatly impact the management of underwater cultural heritage. While by no means definitive, this research provides a general base from which a number of possible studies could be developed. By drawing together literature from a wide number of disciplines and combining it with the questionnaire results, a comprehensive review has been created of current methods and uses of in situ preservation. By reviewing the scientific foundations of in situ preservation, it has been demonstrated that current research supports the use of in situ preservation when appropriately applied and this research continues to provide usable data for practitioners. Beyond providing new avenues for research, it is hoped that this work will encourage discussion on a number of levels that will lead to better preservation of underwater cultural heritage.

The future of in situ preservation and storage is one of continued research. There is still much to learn about the deterioration of archaeological materials in both exposed and buried marine environments. But there are other issues associated with in situ preservation and storage that deserve to be investigated. One such area is the uneasy relationship between government bureaucracies and the archaeologists and cultural resource managers they employ. As identified in the questionnaire, this relationship impacts heavily on the types of site protection afforded underwater cultural heritage. If agencies fail to grasp the implications that a “do-nothing” approach has for underwater sites, the public may come to equate in situ preservation with the continued destruction of underwater cultural heritage.

Educating those who are responsible for funding the preservation of underwater cultural heritage will be perhaps the most difficult trial for those practicing in situ techniques. Governments in particular are known to cut funding to culture, especially in difficult economic times. Those responsible for ensuring their spending does not exceed their budget will be hard pressed to understand the implications for heritage that cannot be readily seen or accessed. “Out of sight, out of mind” remains a continued issue in submerged cultural resource
management. The development of a clear definition of *in situ* preservation and storage will prevent the methods from continuing to be associated with a “do-nothing” mindset.

Another area in which *in situ* preservation and storage stands to play an important role is in the development of the underwater museum. Public access continues to be at the heart of many cultural resource management debates. Providing an entrée into an arena that many members of the public cannot access will be an integral part of future management plans. By preserving sites *in situ* and making use of new technologies, such as telelink and the internet, a large portion of the public will be able to virtually “visit” underwater sites. This may aid in accessing higher levels of funding for future projects by actively involving the public.

The underwater museum will also be a challenge for those developing *in situ* techniques. Many of the techniques employed presently cannot be reconciled with public access. Reburial by its very nature blocks access. So do other techniques, such as geotextiles and artificial seagrass, which encourage sedimentation. The development of *in situ* techniques that will serve to both preserve the site and allow access will be a necessary avenue for research. Such research also has the potential to lead to a better understanding of public impacts on sites.

*In situ* storage could in the long run prove to be an economical way to store cultural material. At present, museums have little space in which to store and display large collections of waterlogged material. Conservation and storage costs are often prohibitive. Research into the development of underwater storage areas could be a possible solution that will allow archaeologists to continue to excavate submerged sites. Results from projects such as RAAR could be utilised as a starting point for new research into site-specific applications. Integral to the development of storage areas is further research into the practical and administrative challenges, such as accessing items and ensuring environmental storage levels are met and maintained. Thomas Bergstrand has begun to explore these questions in the RAAR project and other projects undertaken with the Bohus County museum in Sweden (Bergstrand 2002, pp. 161-162; Bergstrand & Nyström Godfrey 2007, p. 8). It may be assumed that, like the *in situ* processes
themselves, challenges to administration and access will need to be investigated on an area-specific basis.

On 2 January 2009, the UNESCO Convention for the Protection of the Underwater Cultural Heritage entered into force. This document recognises in situ preservation and storage as an important device in the tool kit of maritime archaeologists and submerged cultural heritage managers. It is important that in situ preservation and storage is understood in terms of its definitions and capabilities. This thesis explored the current attitudes held towards in situ preservation and storage. It demonstrated through both a review of the literature and practitioner questionnaire that in situ preservation is a dynamic field relying heavily on interdisciplinary discourse. Practitioners do, on the whole, support in situ techniques, but have some very specific requirements for further research and use. As one respondent stated, ‘The in situ [sic] protection of sites is an integrated part of this management process. Recent international standards state that in-situ [sic] preservation is the first option to be considered when managing a site. Not the “best” option, as some would have us believe, but the “first” option. If there is good reason to intrusively investigate a site, then that may be a viable option. In situ [sic] preservation is simply one tool in the archaeologist’s armoury, albeit an important and useful one.’
Appendix A: Practitioner Questionnaire

In situ preservation and storage of materials from submerged maritime sites

Preservation of waterlogged archaeological materials found in maritime, submerged or terrestrial environments has always posed difficulties for archaeologists and conservators. It is well known that, while a larger number of artefacts made from a variety of different materials are more likely to be preserved in a waterlogged environment, these items require extensive and often expensive conservation to remain stable in air. Given the costs associated with some of the larger scale projects conducted to date, such as the Mary Rose, Batavia and Vasa, museums, governments and other cultural agencies are finding it more difficult to justify the expenditure involved with these types of projects in order to recover and stabilise such culturally important and physically sensitive materials. Increasingly, it is becoming acceptable practice to preserve or store waterlogged materials in their original environment and not recover and treat them with conventional conservation methods before storing them in typical museum-style settings and storage. However, very little work to date has focused on whether these in situ methods are the best form of preservation for these items. With new research emerging, it is important to understand the methods professionals are choosing when working in submerged environments and the factors that inform their decisions concerning the preservation of these sites, features and artefacts. This questionnaire seeks to explore current practices and viewpoints about the use of in situ preservation or in situ storage when dealing with submerged maritime sites and materials.
Definitions

To clarify interpretation, the following definitions have been used in creating this survey.

Archaeological survey
A non-destructive survey that records the site partially or in its entirety by means of all or any of the following: photographic and videographic media; conventional forms of measurement such as baseline offsets, trilateration and drawing frames; electronic forms of measurement such as total station; and any other form of site recording that does not include excavation in any form.

Conservation survey
Any form of survey that collects information on site conditions, be they environmental, physical, chemical or biological, that can be used to inform conservation programmes for the site, features or artefacts, separately or as a whole, either conventional or in situ.

Excavation
Any activity on a site involving the recovery of data via disturbance of sediments, whether it is a test pit, a trench or full recovery of the contents of the site.

In situ preservation
Any steps taken on or intervention with a site in order to extend its longevity while maintaining original context and spatial position; while artefacts and features may have been excavated and/or removed, the site itself remains in place and retains all or a majority of its original context.

In situ storage
Any steps taken to preserve the physical, historical and aesthetic integrity of artefacts and features excavated from a site through the creation of a separate space where items are stored within the confines of an environment similar or deemed to be more beneficial to that from which they were removed.

Maritime archaeology
The study of human interaction with the sea through seafaring; this includes not only the vessels themselves, but port and harbour structures; fishing, whaling and other maritime subsistence activities; lighthouse and shore-based structures that aid in seafaring; and any other type of site that has connections to the use of the sea and its resources by humans.
**Monitoring**

Any observations made regarding either a site, including features and artefacts within it, or a storage area, made by use of human senses or by equipment of any type, that are used to assess the area to inform new procedures, answer research questions, gather information on conservation, or provide an informative view of the area in general.

**Underwater site**

Any site, feature or artefact found in a body of water, whether it be a lake, river or sea; these sites may include those which have become inundated over time and are currently underwater, such as habitation or ceremonial sites.

**Waterlogged terrestrial sites**

For the purposes of this questionnaire, any site that may now be treated as a terrestrial site, but was at some previous time under any body of water such as a lake, river or sea and which people interacted with as a water body for the purposes of transport, subsistence, economy or ceremony. These sites will not include sites which have always been terrestrial but yet waterlogged unless they can be clearly related to the maritime landscape through the above definition of maritime archaeology.
Background Information

1. If you were to describe yourself in terms of your profession, which designation best describes you? Please choose only one.
   - Archaeologist
   - Conservator
   - Cultural Heritage Manager
   - Chemist
   - Biologist
   - Oceanographer
   - Other

2. In which sector are you mainly employed? Please choose only one.
   - Education
   - Government
   - Private/Consulting
   - Not-for-Profit
   - Museum
   - Other

Section A: General Site Questions

1. On what types of sites have you or your organisation worked? Check all that apply.
   - Waterlogged terrestrial sites as defined in this survey
   - Intertidal sites that were:
     - Always waterlogged
     - Always dry
     - Some parts always waterlogged; some parts always dry
     - Subject to fluctuations, with parts that dry out and re-wet
   - Shallow underwater sites (1-10m/3-30ft)
   - Mid depth underwater sites (11-30m/31-100ft)
   - Deep underwater sites (below 30m/100ft)

2. How was the site(s) situated in relation to its environment? Check all that apply.
   - Completely exposed, or proud of the sediment
   - Completely buried in sediment
   - Partially exposed and partially buried
   - Varied; site was constantly in flux, subjected to exposure/reburial cycles
   - Other

3. What sort of work was conducted on the site? Check all that apply.
   - Archaeological survey as per the definitions
   - Conservation survey as per the definitions
Excavation as per the definitions
Other

4. If a conservation survey was conducted, what type of information was collected/processed? Check all that apply.

- Water temperature
- Salinity
- Water pH
- Other types of chemical analysis on collected water
- Redox potential of water
- Sediment composition
- Corrosion potential of metals
- Visual inspection of materials
- Chemical analysis of materials
- Other

5. If excavations occurred, what was done with the cultural material? Check all that apply.

- Recovery coupled with conventional conservation and storage
- In situ preservation
- In situ storage
- Recorded/analysed then destroyed
- Other

6. What types of materials were found on the site? Check all that apply.

- Wood, cellulose organics
- Leather, bone, shell, antler/horn
- Ferrous metals
- Non-ferrous metals
- Silicates, porcelain, stone
- Other

Please make any additional comments you feel are important about general site conditions in the space below.
Section B: *In Situ* Preservation and Storage

1. Have you or your organisation used *in situ* preservation or storage and how often is it employed on sites?
   - □ Yes, once
   - □ Yes, sometimes
   - □ Yes, often
   - □ Yes, always
   - □ No, never; if so, proceed to Question 13

2. Would you or your organisation continue to use *in situ* preservation or storage as a method of conservation?
   - □ Yes; if so, continue to Question 5
   - □ No; if so, continue to next question

3. If you answered ‘no’ to the Question 2, what factors have contributed to the decision to not use *in situ* preservation or storage as a method of preservation? Check all that apply.
   - □ Equipment and/or materials required in preservation process are difficult to access
   - □ Time constraints
   - □ Insufficient professional personnel available
   - □ Insufficient volunteer personnel available
   - □ Insufficient training of current personnel and/or volunteers
   - □ Internal policies of organisation
   - □ Governmental legislation
   - □ Governmental/agency permitting difficulties
   - □ Financial
   - □ Not convinced of reliability/suitability by current research
   - □ Other

4. What, if anything, would convince you or your organisation to use *in situ* preservation or storage for future work? Check all that apply, then proceed to Section C.
   - □ Better access to necessary equipment and/or materials required for preservation process
   - □ More time available for process
   - □ More professional personnel available
   - □ More volunteer personnel available
   - □ Better training for professional and/or volunteer personnel
   - □ New or updated internal policies
   - □ New or updated government legislation
   - □ Permitting system with less associated difficulties
   - □ More money available for projects
   - □ New research supporting the benefits of *in situ* preservation/storage
   - □ Nothing could convince me of its feasibility
   - □ Other
5. If you answered ‘yes’ to question 2, would you use the same preservation programme?
   □ The same as conducted previously; if so, continue on to Question 7
   □ Different from what was conducted previously
   □ It would depend

6. If you were to make changes or consider a different approach, what would inform your decisions? Check all that apply.
   □ Each site requires a preservation programme specifically developed for that site
   □ Changes in structure have occurred in the organisation that necessitate changes to internal programmes
   □ Finances available to specific projects
   □ New research and techniques have become available
   □ Other

7. What form(s) of in situ preservation or storage have you or your organisation used on project(s)? Check all that apply.
   □ Reburial with backfill with sediment excavated from site
   □ Reburial via sediment drop with sediment brought to site from elsewhere
   □ Artificial sea grass
   □ Shade cloth/debris nets
   □ Tarpaulin/geotextiles
   □ Sandbags
   □ Excavation and reburial of materials in a different area (in situ storage)
   □ Other

8. If in situ storage was used rather than in situ preservation, why? Check all that apply.
   □ Development threatened current site
   □ Environment on site threatened preservation
   □ Site was dangerous to shipping, commerce or recreation
   □ Government legislation and/or policy required removal
   □ Other

9. If materials were removed from their original site and reburied elsewhere, what was the new environment?
   □ Similar to the original environment in terms of sediment, pH, redox, etc.
   □ Different to the original environment in terms of sediment, pH, redox, etc.; if so, why?

10. If you reburied materials either on the original site or in a designated storage area, were materials packaged before being reburied?
    □ Yes; if so, proceed to Question 11
    □ No; if so, proceed to Question 12
11. If you used packing materials and other items associated with packing, what types were used? Check all that apply.

- Crates
- Wood
- Polyethylene
- Other
- Bags
- Geotextiles
- Wadding
- Cord
- Tags
- Markers, pens, pencils, etc.

12. If you did not use packaging, why? Check all that apply.

- Materials are difficult to access
- Time constraints
- Insufficient professional personnel available
- Insufficient volunteer personnel available
- Insufficient training of current personnel and/or volunteers
- Internal policies of organisation
- Governmental legislation
- Governmental/agency permitting difficulties
- Financial
- Didn’t believe it was necessary
- Other

13. If you answered ‘no’ to the Question 1, what factors have contributed to the decision to not use in situ preservation or storage as a method of conservation? Check all that apply.

- Equipment and/or materials required in preservation process are difficult to access
- Time constraints
- Insufficient professional personnel available
- Insufficient volunteer personnel available
- Insufficient training of current personnel and/or volunteers
- Internal policies of organisation
- Governmental legislation
- Governmental/agency permitting difficulties
- Financial
- Site conditions, such as accessibility, depth
- Materials were too degraded
- Materials were not culturally, historically or aesthetically significant
- Not convinced of reliability/suitability by current research
- Other
14. What, if anything, would convince you or your organisation to use *in situ* preservation or storage for future work? Check all that apply.

- Better access to necessary equipment and/or materials required for preservation process
- More time available for process
- More professional personnel available
- More volunteer personnel available
- Better training for professional and/or volunteer personnel
- New or updated internal policies
- New or updated government legislation
- Permitting system with less associated difficulties
- More money available for projects
- New research supporting the benefits of *in situ* preservation/storage
- Nothing could convince me of its feasibility
- Other

Please make any additional comments you feel are important about *in situ* preservation and storage in the space below.

**Section C: Site Monitoring**

1. Regardless of whether or not *in situ* preservation or storage was used, do you or your organisation have a site monitoring plan for site(s) you have investigated?

- Yes; if so, proceed to Question 2
- No; if so, proceed to Question 8

2. If you do monitor sites, do you have a formal schedule for this work?

- Yes, we have a formal schedule; if so, briefly, how is it scheduled and what types of procedures does it entail?
- No; it is dependent on a number of factors including available time, funds and personnel as well as site location and conditions

3. Why do you monitor the site(s)?

- To ensure the integrity of the site and for updating necessary site plans
- To ensure the integrity of the site and monitor *in situ* preservation or storage
- Other

4. What types of monitoring do you use on the site(s)? Check all that apply.

- Visual monitoring, including photography, videography and notes
- Materials sampling and analysis
- Sediment sampling and analysis
- Corrosion measurements
- Other

5. What types of equipment do you use during your monitoring? Check all that apply.
Cameras and/or video equipment
Dipwells, in-situ sampling and subsequent analysis
Electrodes, in-situ or ex-situ water/corrosion/sediment measurements
None
Other

6. Do you have monitoring equipment set up on site permanently?
   - Yes
   - No; single use equipment is brought in each time
   - No; samples are collected on site and analysed ex-situ

7. Are there any changes you would make to your current site monitoring processes? Explain briefly

8. If you answered ‘no’ to Question 1, why? Check all that apply.
   - Equipment and/or materials required for monitoring procedures are difficult to access
   - Time constraints
   - Insufficient professional personnel available
   - Insufficient volunteer personnel available
   - Insufficient training of current personnel and/or volunteers
   - Internal policies of organisation
   - Government legislation
   - Governmental/agency permitting difficulties
   - Financial
   - Didn’t believe it was necessary
   - Other

9. What if anything would convince you or your organisation to monitor sites in the future? Check all that apply.
   - Better access to necessary equipment and/or materials required for monitoring procedures
   - More time available for process
   - More professional personnel available
   - More volunteer personnel available
   - Better training for professional and/or volunteer personnel
   - New or updated internal policies
   - New or updated government legislation
   - Permitting system with less associated difficulties
   - More money available for projects
   - New research supporting the benefits of monitoring in situ preservation/storage
   - Nothing could convince me of its feasibility
   - Other

Please make any additional comments you feel are important about site monitoring in the space below.
Appendix B: Results by Question for Practitioner Questionnaire

Background Information

If you were to describe yourself in terms of your profession, which designation best describes you? Please choose only one.

<table>
<thead>
<tr>
<th>Career</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archaeologist</td>
<td>53</td>
<td>59.6%</td>
</tr>
<tr>
<td>Conservator</td>
<td>14</td>
<td>15.7%</td>
</tr>
<tr>
<td>Cultural Heritage Manager</td>
<td>12</td>
<td>13.5%</td>
</tr>
<tr>
<td>Other</td>
<td>10</td>
<td>11.2%</td>
</tr>
<tr>
<td>Total</td>
<td>89</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Responses to “Other”
1. Maritime Archaeology Student
2. Curator of Maritime Archaeology
3. Museum curator, maritime archaeology and history
4. Shipwreck Explorer
5. Engineer/archaeologist
6. Site recording specialist
7. Teacher
8. Maritime Archaeologist
9. Museum curator
10. Conservation Scientist
In which sector are you mainly employed? Please choose only one

<table>
<thead>
<tr>
<th>Sector</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>15</td>
<td>16.9%</td>
</tr>
<tr>
<td>Government</td>
<td>38</td>
<td>42.7%</td>
</tr>
<tr>
<td>Private/Consulting</td>
<td>15</td>
<td>16.9%</td>
</tr>
<tr>
<td>Not-for-Profit</td>
<td>4</td>
<td>4.5%</td>
</tr>
<tr>
<td>Museum</td>
<td>16</td>
<td>18.0%</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>1.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>89</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>

Responses to “Other”
1. PhD. student
## Part A

**A1. On what types of sites have you or your organisation worked? Check all that apply.**

<table>
<thead>
<tr>
<th>A1</th>
<th>Responses</th>
<th>N</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterlogged terrestrial sites as defined in this survey</td>
<td>49</td>
<td></td>
<td>11.3%</td>
<td>56.3%</td>
</tr>
<tr>
<td>Intertidal sites that were always waterlogged</td>
<td>53</td>
<td></td>
<td>12.2%</td>
<td>60.9%</td>
</tr>
<tr>
<td>Intertidal sites that were always dry</td>
<td>27</td>
<td></td>
<td>6.2%</td>
<td>31.0%</td>
</tr>
<tr>
<td>Intertidal sites in which some parts were always waterlogged while some parts always dry</td>
<td>50</td>
<td></td>
<td>11.5%</td>
<td>57.5%</td>
</tr>
<tr>
<td>Intertidal sites that were subject to fluctuations, with parts that dry out and re-wet</td>
<td>50</td>
<td></td>
<td>11.5%</td>
<td>57.5%</td>
</tr>
<tr>
<td>Shallow underwater sites (1-10m/3-30ft)</td>
<td>80</td>
<td></td>
<td>18.5%</td>
<td>92.0%</td>
</tr>
<tr>
<td>Mid depth underwater sites (11=3-m/31-100ft)</td>
<td>78</td>
<td></td>
<td>18.0%</td>
<td>89.7%</td>
</tr>
<tr>
<td>Deep underwater sites (below 30m/100ft)</td>
<td>46</td>
<td></td>
<td>10.6%</td>
<td>52.9%</td>
</tr>
<tr>
<td>Total</td>
<td>433</td>
<td></td>
<td>100.0%</td>
<td>497.7%</td>
</tr>
</tbody>
</table>
A2. How was the site(s) situated in relation to its environment? Check all that apply.

<table>
<thead>
<tr>
<th>A2</th>
<th>Responses</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completely exposed or proud of the sediment</td>
<td>52</td>
<td>20.0%</td>
<td>60.5%</td>
</tr>
<tr>
<td>Completely buried in sediment</td>
<td>59</td>
<td>22.7%</td>
<td>68.6%</td>
</tr>
<tr>
<td>Partially exposed and partially buried</td>
<td>74</td>
<td>28.5%</td>
<td>86.0%</td>
</tr>
<tr>
<td>Varied; site was constantly in flux, subjected to exposure/reburial</td>
<td>71</td>
<td>27.3%</td>
<td>82.6%</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>1.5%</td>
<td>4.7%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>260</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>302.3%</strong></td>
</tr>
</tbody>
</table>

Responses to “Other”

1. Large artifacts exposed (cannon & anchors), remains of hull covered by thin layer of coral growth
2. In reclamation
3. Shipwreck site on terrestrial site, partly and occasionally waterlogged
4. Sites that used to be underwater all the time but are now on land: reclaimed land "polder" area
A3. What sort of work was conducted on the site? Check all that apply.

<table>
<thead>
<tr>
<th>A3</th>
<th>Responses</th>
<th>N</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archaeological survey as per the definitions</td>
<td></td>
<td>77</td>
<td>37.6%</td>
<td>92.8%</td>
</tr>
<tr>
<td>Conservation survey as per the definitions</td>
<td></td>
<td>49</td>
<td>23.9%</td>
<td>59.0%</td>
</tr>
<tr>
<td>Excavation as per the definitions</td>
<td></td>
<td>72</td>
<td>35.1%</td>
<td>86.7%</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>7</td>
<td>3.4%</td>
<td>8.4%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>205</td>
<td>100.0%</td>
<td>247.0%</td>
</tr>
</tbody>
</table>

Responses to “Other”
1. Monitoring
2. Monitoring of in situ conservation methods - anodes attached to anchors
3. Testing - including surface collection
4. In situ preservation, monitoring, reburial ex situ under ground water level
5. [Site] was raised and excavated on the surface, while the site was salvaged to reasonable standards by navy divers …
6. In situ stabilisation
7. Taking measures for physical protection (covering the site with sandbags and or maze)
A4. If a conservation survey was conducted, what type of information was collected/processed? Check all that apply.

<table>
<thead>
<tr>
<th></th>
<th>Responses</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water temperature</td>
<td>46</td>
<td>13.1%</td>
<td>78.0%</td>
</tr>
<tr>
<td>Salinity</td>
<td>46</td>
<td>13.1%</td>
<td>78.0%</td>
</tr>
<tr>
<td>Water pH</td>
<td>46</td>
<td>13.1%</td>
<td>78.0%</td>
</tr>
<tr>
<td>Other types of chemical analysis on collected water</td>
<td>23</td>
<td>6.5%</td>
<td>39.0%</td>
</tr>
<tr>
<td>Redox potential of water</td>
<td>23</td>
<td>6.5%</td>
<td>39.0%</td>
</tr>
<tr>
<td>Sediment composition</td>
<td>37</td>
<td>10.5%</td>
<td>62.7%</td>
</tr>
<tr>
<td>Corrosion potential of metals</td>
<td>35</td>
<td>9.9%</td>
<td>59.3%</td>
</tr>
<tr>
<td>Visual inspection of materials</td>
<td>55</td>
<td>15.6%</td>
<td>93.2%</td>
</tr>
<tr>
<td>Chemical analysis of materials</td>
<td>30</td>
<td>8.5%</td>
<td>50.8%</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>3.1%</td>
<td>18.6%</td>
</tr>
<tr>
<td>Total</td>
<td>352</td>
<td>100.0%</td>
<td>596.6%</td>
</tr>
</tbody>
</table>

Responses to “Other”
1. Metallurgical analysis of materials
2. Turbidity of water, grain particle size, current monitoring
3. Bacterial analysis
4. Dissolved oxygen and wood id
5. Petrography, XRF, XRD, IC, SEM on selected materials. Risk & Condition Assessments. Assessment of Heritage Significance, Stabilisation specifications
6. Surface pH of corroding metal
7. Dissolved oxygen, sedimentation-erosion, water content, biological deterioration
8. Proxy redox measurements, (i.e., H2S levels as a proxy for reducing environment)
9. Sediment micromorphology, internal wave datalogger, sediment bulk properties (water content, particle size, etc.), artefact micromorphology, wood bacteriology
10. Some of this information was gathered, but I cannot give details. It wasn’t a comprehensive study.
11. Species identification (timbers)
A5. If excavations occurred, how was the cultural material handled? Check all that apply.

<table>
<thead>
<tr>
<th>A5</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Recovery coupled with conventional conservation and storage</td>
<td>79</td>
</tr>
<tr>
<td>In situ preservation</td>
<td>55</td>
</tr>
<tr>
<td>In situ storage</td>
<td>30</td>
</tr>
<tr>
<td>Recorded/analysed then destroyed</td>
<td>16</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>185</td>
</tr>
</tbody>
</table>

Responses to “Other”
1. Non-diagnostic artifacts returned to the site in specially marked bags and labelled
2. Recorded, analysed then disposed
3. Terrestrial shipwreck was reburied after documentation
4. Recovery and documentation followed by reburial
5. Recovery for documentation, then reburial on site
A6. What types of materials were found on the site? Check all that apply.

<table>
<thead>
<tr>
<th>A6</th>
<th>N</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood, cellulose organics</td>
<td>81</td>
<td>20.7%</td>
<td>97.6%</td>
</tr>
<tr>
<td>Leather, bone, shell, antler/horn</td>
<td>69</td>
<td>17.6%</td>
<td>83.1%</td>
</tr>
<tr>
<td>Ferrous metals</td>
<td>81</td>
<td>20.7%</td>
<td>97.6%</td>
</tr>
<tr>
<td>Non-ferrous metals</td>
<td>74</td>
<td>18.9%</td>
<td>89.2%</td>
</tr>
<tr>
<td>Silicates, porcelain, stone</td>
<td>76</td>
<td>19.4%</td>
<td>91.6%</td>
</tr>
<tr>
<td>Other</td>
<td>10</td>
<td>2.6%</td>
<td>12.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>391</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>471.1%</strong></td>
</tr>
</tbody>
</table>

Responses to “Other”
1. Paper
2. Beads and glass
3. Wax candle (sperm whale)
4. In one case rubber (tiles on a submarine to deaden acoustics)
5. Human remains
6. Chipped stone
7. Paleobotanic: seeds etc, insects, liquids, lace
8. Fibre, plant materials, textiles - you may be classing these under “Wood, cellulose organics”, but just in case not....
9. Cloth
10. Rope, seeds gunpowder
Please make any additional comments you feel are important about general site conditions in the space below.

1. Left 25 cannon on site, excavated one and put in fresh water conservation tank.
2. The site… was very close to the shore (less than 100 metres). It is a very dynamic site, and with the action of the waves and the unforgiving nature of ice during winter, very little would have survived for long after the remains were exposed after a storm.
3. Dynamic coast means that only rarely would in situ preservation be possible. The expense of continuously restabilising sites [is] often prohibitive.
4. I have worked on lots of sites over the years with many organisations, so have commented on these. Many different organisations did things differently. Some undertook whole excavation of sites. Some survey. Some reburied organics on site. Some did on site conservation (eg. anodes, etc.).
5. These answers are coming [from] projects that range across all of the options in terms of environment and intent of research, so answers are not necessarily site-specific. All that to say, it completely depended on the researcher, the site, and resources what was done at each site.
6. Wild west coast surf conditions – sand
7. Difficult to generalize about sites as there is much variation
8. A lot of these sites - exposure was an environmental process (or changes in sediment regimes due to human action nearby had led to exposure). In these cases the question of in situ preservation becomes very difficult - it essentially means intervention which is not always sustainable nor cost-effective.
9. Site conditions were cold water, shallow, with a highly organic sediment. Evidence within the wood structure of previous exposure to wood-boring organisms (toredo) post-deposition: although, no current records of wood-boring organisms in the area.
10. A6. refers to "the site". Am I meant to think of only one site? I've answered referring to several sites.
11. I have over 20 years experience working on submerged and intertidal sites in widely varying conditions, so the above answers reflect the breadth of that experience rather than a specific site.
12. Sites vary from turbulent to still water with heavy silt loads and from saline to fresh.
13. One particular site is in extremely deep water - 4,000 feet. Many of the above listed analyses were conducted on this site as the effects of deep-water in situ preservation are not yet well understood.
14. Only very limited recovery of cultural materials in undertaken by program
Part B

B1. Have you or your organisation used *in situ* preservation or storage and how often is it employed on sites?

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, once</td>
<td>8</td>
<td>9.0%</td>
<td>9.0%</td>
<td>9.0%</td>
</tr>
<tr>
<td>Yes, sometimes</td>
<td>32</td>
<td>36.0%</td>
<td>36.0%</td>
<td>44.9%</td>
</tr>
<tr>
<td>Yes, often</td>
<td>24</td>
<td>27.0%</td>
<td>27.0%</td>
<td>71.9%</td>
</tr>
<tr>
<td>Yes, always</td>
<td>6</td>
<td>6.7%</td>
<td>6.7%</td>
<td>78.7%</td>
</tr>
<tr>
<td>No</td>
<td>13</td>
<td>14.6%</td>
<td>14.6%</td>
<td>93.3%</td>
</tr>
<tr>
<td>No Response</td>
<td>6</td>
<td>6.7%</td>
<td>6.7%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Total</td>
<td>89</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
B2. Would you or your organisation continue to use *in situ* preservation or storage as a method of conservation?

<table>
<thead>
<tr>
<th>B2</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>66</td>
<td>85.7%</td>
<td>85.7%</td>
<td>85.7%</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>3.9%</td>
<td>3.9%</td>
<td>89.6%</td>
</tr>
<tr>
<td>No Response</td>
<td>8</td>
<td>10.4%</td>
<td>10.4%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Total</td>
<td>77</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
B3. If you or your organisation would not continue to use *in situ* methods, what factors have contributed to the decision to not use *in situ* preservation or storage as a method of preservation? Check all that apply.

<table>
<thead>
<tr>
<th>B3</th>
<th>Responses</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment and/or materials required in preservation process are difficult to access</td>
<td>3</td>
<td>25.0%</td>
<td>75.0%</td>
</tr>
<tr>
<td>Time constraints</td>
<td>1</td>
<td>8.3%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Insufficient professional personnel available</td>
<td>2</td>
<td>16.7%</td>
<td>50.0%</td>
</tr>
<tr>
<td>Insufficient volunteer personnel available</td>
<td>0</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Insufficient training of current personnel and/or volunteers</td>
<td>1</td>
<td>8.3%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Internal policies of organisation</td>
<td>0</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Governmental legislation</td>
<td>1</td>
<td>8.3%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Governmental/agency permitting difficulties</td>
<td>0</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Financial</td>
<td>1</td>
<td>8.3%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Not convinced of reliability/suitability by current</td>
<td>1</td>
<td>8.3%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>16.7%</td>
<td>50.0%</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>100.0%</td>
<td>300.0%</td>
</tr>
</tbody>
</table>

Responses to “Other”
1. Insufficient current research into the long term affects of *in situ* (for organics) storage: [a specialist in the field] has spoken to me a lot about this in the past & is very sceptical about this technique. This is mainly for *in situ* storage not preservation.
2. Depends on circumstances, but *in situ* is not necessarily best option
B4. What, if anything, would convince you or your organisation to use *in situ* preservation or storage for future work? Check all that apply.

<table>
<thead>
<tr>
<th>B4</th>
<th>Responses</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better access to necessary equipment and/or materials required for preservation process</td>
<td>1</td>
<td>12.5%</td>
<td>25.0%</td>
</tr>
<tr>
<td>More time available for process</td>
<td>0</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>More professional personnel available</td>
<td>2</td>
<td>25.0%</td>
<td>50.0%</td>
</tr>
<tr>
<td>More volunteer personnel available</td>
<td>0</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Better training for professional and/or volunteer personnel</td>
<td>1</td>
<td>12.5%</td>
<td>25.0%</td>
</tr>
<tr>
<td>New or updated internal policies</td>
<td>0</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>New or updated government legislation</td>
<td>0</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Permitting system with less associated difficulties</td>
<td>0</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>More money available for projects</td>
<td>1</td>
<td>12.5%</td>
<td>25.0%</td>
</tr>
<tr>
<td>New research supporting the benefits of <em>in situ</em> preservation/storage</td>
<td>1</td>
<td>12.5%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Nothing could convince me of its feasibility</td>
<td>0</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>25.0%</td>
<td>50.0%</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>100.0%</td>
<td>200.0%</td>
</tr>
</tbody>
</table>

Responses to “Other”
1. We do not need convincing, it depends on circumstances
2. Certainly that we would be learning something about the past from the site and the I[n] S[itu] was not be used as a way of ignoring the management problem
B5. If you or your organisation would continue to use *in situ* methods, would you use the same preservation programme?

<table>
<thead>
<tr>
<th>B5</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>7</td>
<td>9.1%</td>
<td>9.1%</td>
<td>9.1%</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
<td>1.3%</td>
<td>1.3%</td>
<td>10.4%</td>
</tr>
<tr>
<td>It Depends</td>
<td>58</td>
<td>75.3%</td>
<td>75.3%</td>
<td>85.7%</td>
</tr>
<tr>
<td>No Response</td>
<td>11</td>
<td>14.3%</td>
<td>14.3%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Total</td>
<td>77</td>
<td>100.0%</td>
<td>100.0%</td>
<td></td>
</tr>
</tbody>
</table>
B6. If you were to make changes or consider a different approach, what would inform your decisions? Check all that apply.

<table>
<thead>
<tr>
<th>B6</th>
<th>Responses</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each site requires a preservation programme specifically developed for that site</td>
<td>56</td>
<td>32.8%</td>
<td>91.8%</td>
</tr>
<tr>
<td>Changes in structure have occurred in the organisation that necessitate changes to internal policies</td>
<td>8</td>
<td>4.7%</td>
<td>13.1%</td>
</tr>
<tr>
<td>Finances available to specific projects</td>
<td>50</td>
<td>29.2%</td>
<td>82.0%</td>
</tr>
<tr>
<td>New research and techniques have become available</td>
<td>51</td>
<td>29.8%</td>
<td>83.6%</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>3.5%</td>
<td>9.8%</td>
</tr>
<tr>
<td>Total</td>
<td>171</td>
<td>100.0%</td>
<td>280.3%</td>
</tr>
</tbody>
</table>

Responses to “Other”
1. International collaborative research ongoing
2. Research question
3. Significance potential of the site
4. Archaeological Significance of site/Public value
5. Goals can vary. Some sites may be developed as underwater museums as the technology (e.g.: telepresence) evolves.
6. Potential danger to site
B7. What form(s) of *in situ* preservation or storage have you or your organisation used on project(s)? Check all that apply.

<table>
<thead>
<tr>
<th>B7</th>
<th>Responses</th>
<th>N</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reburial with backfill with sediment</td>
<td></td>
<td>50</td>
<td>25.1%</td>
<td>78.1%</td>
</tr>
<tr>
<td>excavated from site</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reburial via sediment drop with sediment</td>
<td></td>
<td>19</td>
<td>9.5%</td>
<td>29.7%</td>
</tr>
<tr>
<td>brought to site from elsewhere</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Artificial sea grass</td>
<td></td>
<td>10</td>
<td>5.0%</td>
<td>15.6%</td>
</tr>
<tr>
<td>Shade cloth/debris netting</td>
<td></td>
<td>21</td>
<td>10.6%</td>
<td>32.8%</td>
</tr>
<tr>
<td>Tarpaulin/geotextiles</td>
<td></td>
<td>19</td>
<td>9.5%</td>
<td>29.7%</td>
</tr>
<tr>
<td>Sandbags</td>
<td></td>
<td>43</td>
<td>21.6%</td>
<td>67.2%</td>
</tr>
<tr>
<td>Excavation and reburial of materials in a</td>
<td></td>
<td>26</td>
<td>13.1%</td>
<td>40.6%</td>
</tr>
<tr>
<td>different area (<em>in situ storage</em>)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>11</td>
<td>5.5%</td>
<td>17.2%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>199</td>
<td>100.0%</td>
<td>278.1%</td>
</tr>
</tbody>
</table>

Responses to “Other”

1. Leaving underwater sites as is for future use as Underwater Archaeological Preserve or Underwater Parks
2. Build up of site with perimeter of ‘road lego’
3. Left as found
4. Indirect sediment deposition and natural transfer of sediment to cover site.
5. Reburial of materials in different areas not due to excavation but to storm re-deposition
6. We don't do in situ preservation as much as we do in situ conservation analysis and storage
7. Regular monitoring of known sites
8. I work with archaeological monuments and historic buildings therefore different principles & methods apply
9. Cathodic protection of a cast iron cannon with a sacrificial anode
10. Non-reburial storage- construction of open water depots adjacent to wreck site in anoxic waters for the storage of excavated amphorae.
11. Sorry, not directly involved
B8. If *in situ* storage was used rather than *in situ* preservation, why? Check all that apply.

<table>
<thead>
<tr>
<th>B8</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Development threatened current site</td>
<td>15</td>
</tr>
<tr>
<td>Environment on site threatened preservation</td>
<td>16</td>
</tr>
<tr>
<td>Site was dangerous to shipping, commerce or recreation</td>
<td>3</td>
</tr>
<tr>
<td>Government legislation and/or policy required removal</td>
<td>3</td>
</tr>
<tr>
<td>Not applicable</td>
<td>25</td>
</tr>
<tr>
<td>Other</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>77</td>
</tr>
</tbody>
</table>
Responses to “Other”

1. In situ storage to keep artifacts recovered for research purposes
2. The wreck was reburied in a lake. Climatic conditions in the area would have complicated the actual monitoring of the remains
3. Cannon was moved off wrecksite to allow access to hull, cannon stored on site,
4. Cost was a factor - re: conservation of organic artefacts
5. Frequently visited by looters and sport divers
6. Excavated artefacts are easier to re-locate if reburied all together in a specified location, and less likely to re-erode out of sediment.
7. Cost
8. After complete excavation we sometimes rebury ship parts for future research under the groundwater table on land. Important reason is the lack of funding for conservation, the reason that there is no immediate need for conservation. Underwater best place to keep the timbers well and they are available (more or less) for future research.
9. Proper study of a ship structure requires full excavation and reverse engineering. After a structure is destroyed preservation in situ is not an option.
10. Looting threatened site
11. My reading of your definitions is that in-situ storage refers to artifacts while in-situ preservation refers to the site (including its artifacts). Because of cost/technology limitations deepwater archaeology cannot commit to whole site excavation so in-situ (site) preservation will be done by default. Amphorae and ballast are the only stored artifacts chosen for robustness.
12. We are considering it in association with our conservators.
13. Research excavation but no funding for conservation
14. Large volume of some artefact materials (dunnage, bottle fragments) made conservation very difficult/expensive - reburied/stored materials on site not vital to archaeological research
15. Potential loss of exposed artifacts to souvenir-seeking sport divers
B9. If materials were removed from their original site and reburied elsewhere, what was the new environment?

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Applicable</td>
<td>30</td>
<td>39.5%</td>
<td>39.5%</td>
<td>39.5%</td>
</tr>
<tr>
<td>Similar Environment</td>
<td>23</td>
<td>30.3%</td>
<td>30.3%</td>
<td>69.8%</td>
</tr>
<tr>
<td>Different Environment</td>
<td>8</td>
<td>10.5%</td>
<td>10.5%</td>
<td>80.3%</td>
</tr>
<tr>
<td>No Response</td>
<td>15</td>
<td>19.7%</td>
<td>19.7%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Total</td>
<td>76</td>
<td>100.0%</td>
<td>100.0%</td>
<td></td>
</tr>
</tbody>
</table>

If different, why?
1. Reburial was done in a controlled manner, under a sand shelter, deep into a cold lake in the obscurity. pH of the water is different, but the monitoring has shown that anoxic conditions were reached very rapidly.
2. One site had been partially exposed prior to excavation. Following excavation, it was transferred to another location nearby, but completely reburied under several metres of sediment. pH readings etc were not taken at either site.
3. Have used both similar, close by environments, and very different environments - e.g. estuary to brackish, non-tidal lake.
4. Surface recovered finds were buried on site
5. Not in the same environment: from mainly shipwrecks found in the sea to reburial under groundwater table in fresh water environment.
6. Open water conditions are not identical to the subsurface conditions in the deep portion of this water body. However in essential ways (no life forms above anaerobic bacteria, and little or no current) it is similar to the buried environment. Something only anoxic basins like this water body can supply. The open water environment at the seabed adjacent to the wrecksite is very similar to the buried environment...except that it is open.
7. Timbers were taken from estuary/river to salty lake, some environmental features would be different, however it was the best solution at the time - and timbers remain submerged
8. Material was reburied from different locations in a deep pit under groundwater table.
9. Similar in general terms (close to original site, but in an area less subject to strong scouring.
B10. If you reburied materials either on the original site or in a designated storage area, were materials packaged before being reburied?

<table>
<thead>
<tr>
<th>B10</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>21</td>
<td>27.3%</td>
<td>27.3%</td>
<td>27.3%</td>
</tr>
<tr>
<td>No</td>
<td>31</td>
<td>40.3%</td>
<td>40.3%</td>
<td>67.6%</td>
</tr>
<tr>
<td>No Response</td>
<td>25</td>
<td>32.4%</td>
<td>32.4%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Total</td>
<td>77</td>
<td>100.0%</td>
<td>100.0%</td>
<td></td>
</tr>
</tbody>
</table>
B11. If you used packing materials and other items associated with packing, what types were used? Check all that apply.

<table>
<thead>
<tr>
<th>B11</th>
<th>Responses</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood crates</td>
<td>2</td>
<td>2.6%</td>
<td>9.1%</td>
</tr>
<tr>
<td>Polyethylene crates</td>
<td>6</td>
<td>7.8%</td>
<td>27.3%</td>
</tr>
<tr>
<td>Bags</td>
<td>12</td>
<td>15.6%</td>
<td>54.5%</td>
</tr>
<tr>
<td>Geotextiles</td>
<td>9</td>
<td>11.7%</td>
<td>40.9%</td>
</tr>
<tr>
<td>Wadding</td>
<td>4</td>
<td>5.2%</td>
<td>18.2%</td>
</tr>
<tr>
<td>Cord</td>
<td>8</td>
<td>10.4%</td>
<td>36.4%</td>
</tr>
<tr>
<td>Tags</td>
<td>18</td>
<td>23.4%</td>
<td>81.8%</td>
</tr>
<tr>
<td>Markers, pens, pencils, etc.</td>
<td>12</td>
<td>15.6%</td>
<td>54.5%</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>7.8%</td>
<td>27.3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>77</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>350.0%</strong></td>
</tr>
</tbody>
</table>

Responses to “Other”
1. Anodes
2. Netlon
3. Tanks
4. Large netting-lined cradles capable of holding 12 amphorae [sic] each were deployed.
5. Plastic mesh bags
6. Plastic dymo labels attached to artifacts with nylon line
B12. If you did not use packaging, why? Check all that apply.

<table>
<thead>
<tr>
<th>B12</th>
<th>N</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials are difficult to access</td>
<td>2</td>
<td>4.2%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Time constraints</td>
<td>9</td>
<td>18.8%</td>
<td>32.1%</td>
</tr>
<tr>
<td>Insufficient professional personnel available</td>
<td>2</td>
<td>4.2%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Insufficient Volunteer personnel available</td>
<td>2</td>
<td>4.2%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Insufficient training of current personnel and/or volunteers</td>
<td>1</td>
<td>2.1%</td>
<td>3.6%</td>
</tr>
<tr>
<td>Internal policies of organisation</td>
<td>2</td>
<td>4.2%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Governmental legislation</td>
<td>1</td>
<td>2.1%</td>
<td>3.6%</td>
</tr>
<tr>
<td>Governmental/agency permitting difficulties</td>
<td>0</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Financial</td>
<td>5</td>
<td>10.4%</td>
<td>17.9%</td>
</tr>
<tr>
<td>Didn’t believe it was necessary</td>
<td>17</td>
<td>35.4%</td>
<td>60.7%</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td>14.6%</td>
<td>25.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>48</td>
<td>100.0%</td>
<td>171.4%</td>
</tr>
</tbody>
</table>
Responses to “Other”

1. Unsure, was not present during specified project

2. If placing objects back into an in situ environment i.e. underwater, there is no need for packaging the objects and it would also depend on what was meant by packaging. Packaging would create microclimates and microenvironments that would in some ways negate the positives of placing back into a maritime environment.

3. Packaging encourages different microenvironments that proved hazardous to organic materials in particular

4. On one site, the material was buried under deep sediment and unlikely to ever be revisited so further packaging was deemed unnecessary. On one other site the materials were packaged in net to aid re-identification, and buried under sediment.

5. Such methodologies have not been comprehensively tested and may have detrimental effects

6. Was only done once and the senior partner in the project was the legal owner of the site and made the determination not to do it.

7. Sometimes they were packed but not always and it is a tradition from the 80s. At that time the need was not felt to. We are planning an extensive research on the condition of the reburied wood and then we will see if it was necessary or not
B13. If you or your organisation has never used *in situ* methods, what factors have contributed to the decision to not use these as a method of conservation? Check all that apply.

<table>
<thead>
<tr>
<th>B13</th>
<th>Responses</th>
<th>N</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment and/or materials required in preservation process are difficult to access</td>
<td>1</td>
<td>2.6%</td>
<td>7.7%</td>
<td></td>
</tr>
<tr>
<td>Time constraints</td>
<td>2</td>
<td>5.1%</td>
<td>15.4%</td>
<td></td>
</tr>
<tr>
<td>Insufficient professional personnel available</td>
<td>2</td>
<td>5.1%</td>
<td>15.4%</td>
<td></td>
</tr>
<tr>
<td>Insufficient volunteer personnel available</td>
<td>2</td>
<td>5.1%</td>
<td>15.4%</td>
<td></td>
</tr>
<tr>
<td>Insufficient training of current personnel and/or volunteers</td>
<td>2</td>
<td>5.1%</td>
<td>15.4%</td>
<td></td>
</tr>
<tr>
<td>Internal policies of organisation</td>
<td>3</td>
<td>7.7%</td>
<td>23.1%</td>
<td></td>
</tr>
<tr>
<td>Governmental legislation</td>
<td>1</td>
<td>2.6%</td>
<td>7.7%</td>
<td></td>
</tr>
<tr>
<td>Governmental/agency permitting difficulties</td>
<td>3</td>
<td>7.7%</td>
<td>23.1%</td>
<td></td>
</tr>
<tr>
<td>Financial</td>
<td>5</td>
<td>12.8%</td>
<td>38.5%</td>
<td></td>
</tr>
<tr>
<td>Site conditions, such as accessibility, depth</td>
<td>6</td>
<td>15.4%</td>
<td>46.2%</td>
<td></td>
</tr>
<tr>
<td>Materials were too degraded</td>
<td>2</td>
<td>5.1%</td>
<td>15.4%</td>
<td></td>
</tr>
<tr>
<td>Materials were not culturally, historically or aesthetically significant</td>
<td>1</td>
<td>2.6%</td>
<td>7.7%</td>
<td></td>
</tr>
<tr>
<td>Not convinced of reliability/suitability by current research</td>
<td>4</td>
<td>10.3%</td>
<td>30.8%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>12.8%</td>
<td>38.5%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>39</td>
<td>100.0%</td>
<td>300.0%</td>
<td></td>
</tr>
</tbody>
</table>

Responses to “Other”
1. Authority perceived in situ as a long-term commitment, as if conservation and storage is easier
2. Impossible in the conditions
3. Institution mandate to excavate/document and raise materials
4. We were able to do all of the conservation in the laboratory.
5. Site was small--total recovery was chosen
B14. What, if anything, would convince you or your organisation to use *in situ* preservation or storage for future work? Check all that apply.

<table>
<thead>
<tr>
<th>B14</th>
<th>Responses</th>
<th>N</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better access to necessary equipment and/or materials required for preservation process</td>
<td>3</td>
<td>7.9%</td>
<td>23.1%</td>
<td></td>
</tr>
<tr>
<td>More time available for process</td>
<td>2</td>
<td>5.3%</td>
<td>15.4%</td>
<td></td>
</tr>
<tr>
<td>More professional personnel available</td>
<td>3</td>
<td>7.9%</td>
<td>23.1%</td>
<td></td>
</tr>
<tr>
<td>More volunteer personnel available</td>
<td>1</td>
<td>2.6%</td>
<td>7.7%</td>
<td></td>
</tr>
<tr>
<td>Better training for professional and/or volunteer personnel</td>
<td>4</td>
<td>10.5%</td>
<td>30.8%</td>
<td></td>
</tr>
<tr>
<td>New or updated internal policies</td>
<td>3</td>
<td>7.9%</td>
<td>23.1%</td>
<td></td>
</tr>
<tr>
<td>New or updated government legislation</td>
<td>2</td>
<td>5.3%</td>
<td>15.4%</td>
<td></td>
</tr>
<tr>
<td>Permitting system with less associated difficulties</td>
<td>3</td>
<td>7.9%</td>
<td>23.1%</td>
<td></td>
</tr>
<tr>
<td>More money available for projects</td>
<td>6</td>
<td>15.8%</td>
<td>46.2%</td>
<td></td>
</tr>
<tr>
<td>New research supporting the benefits of <em>in situ</em> preservation/storage</td>
<td>7</td>
<td>18.4%</td>
<td>53.8%</td>
<td></td>
</tr>
<tr>
<td>Nothing could convince me of its feasibility</td>
<td>1</td>
<td>2.6%</td>
<td>7.7%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>7.9%</td>
<td>23.1%</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>38</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>292.3%</strong></td>
<td></td>
</tr>
</tbody>
</table>

Responses to “Other”
1. When applicable, it should be done
2. Site size, quantity of materials, site location, --we have not ruled out in situ storage or preservation and have used it for terrestrial materials
3. Guarantee of continued access for study if needed and protection from looting
Please make any additional comments you feel are important about in situ preservation and storage in the space below.

1. I believe in situ preservation is important so that the sites can be preserved for future generations as parks. Also it is important to keep the sites preserved for future archaeological investigation.

2. When we refer to in situ preservation, it typically occurs in deepwater (greater than 100 metres) where artifacts are documented but left in place.

3. Budgets and facilities for long term preservation were not available. This option was selected after an extensive study of the archaeological material, including photography and full scale drawings of the ship's body.

4. Current position in Pacific Islands: submerged sites tend to be WWII and primarily large metal military objects. Official policy is to leave them as they lie. Also cost and logistics are factors. Previous positions coastal US mainland: fresh and salt water wrecks, intertidal wrecks, 19th century war sites with metal, wood, leather, bone, ceramics, glass. Some materials were collected and professional conservators were hired to treat them. Again, cost of conservation and need for specialized training were factors. Exceptions were made only for well-preserved artifacts with high interpretive value that also had manageable size.

5. Care must be given to restoration of the site to original conditions. Monitor.

6. I'm not entirely sure what is meant by your definition of in situ storage and the difference between that and in situ preservation - from a conservation perspective, surely in situ preservation and in situ storage are the same things? And does your definition of in situ relate to keeping things underwater and in context? That is not so clear in your definitions.

7. My major concerns are (I have in involved in a number of in situ experiments lately, including raising funds for and managing the deployments of I[n] S[itu] systems) 1. In many cases the science behind this is poor and needs development, so are we blowing funds that could be spent excavating and recording the site instead? 2. It is very expensive and requires long term management and expenditure. 3. It provides no research material and does not provide material (not necessarily artifactual) with which we can justify the importance of maritime archaeology. 4. Government is keen to use [n] S[itu] as a way of ignoring maritime archaeology, if you put sandbags on it is preserved and can be ignored, it isn't and it can't.

8. Comments about need for further research are for in situ storage and mainly organics, especially after timber sites are disturbed. There are still problems with acid sulphate soils.

9. In your first question, you ask what our chief area is: I am both an archaeologist and conservator.

10. Only experience was moving a cache of canoes to a more secure location. Nearby but deeper freshwater, on state property, with regular patrol. BUT what if the “safe” place becomes more polluted, or micro environment changes to accelerate biodeterioration? Really feel that state authority regards this as out-of-sight out of mind.

11. When I talk about in situ storage it was primarily for non-diagnostic artifacts recovered that we couldn't keep or preserve, so we returned them, but with no intention of recovering them again in the future.
12. Many sites containing waterlogged materials become exposed during storm events - the changed environment results in rapid degradation from desiccation and from toredo.

13. We are about to start some in situ preservation in the next few weeks by hooking up sacrificial aluminum anodes to artifacts standing proud on the ocean floor.

14. The majority of the projects we currently work on go from Phase I survey to Phase III mitigation as the resource is usually in a construction corridor and will be destroyed unless of considerable historical significance. In that case relocation and reburial might be given consideration.

15. We've actually moved one large artifact (canoe) to a pond that seemed to be the same conditions. It was not and we ended up with new organisms attacking the wood. We try not to do that any more.

16. In situ preservation/reburial is not a universal panacea for maritime archaeology. It is a real tool in the methodology of the profession that can be used in conjunction with a risk management framework. All objects deteriorate, whether in a collection store or in a burial environment. It is the rate of deterioration that differs. If an object is not significant and the risk to it of deterioration from reburial is acceptable using a risk assessment matrix then reburial is an acceptable option to be explored.

17. Successful long-term in situ preservation is dependent upon a reliable dataset of the environmental controls, and a comprehensive knowledge of current impacts and the potential for change in a site's environmental stability. Given the current lack of impetus to garner such information, and the lack of resources available to develop technologies capable of providing such data, preservation in situ should be seen only as a short-term solution. Some current technologies have facilitated the interim deflection of physical, chemical and biological impacts of the marine environment, but such approaches should not be regarded as "final solutions". Furthermore, there are fundamental problems with the strategy that reach beyond long-term conservation - there are issues of public access, the loss of critical archaeological data, and on a broader scale, there are issues with the development of maritime archaeology as an academic pursuit, and the continued regression in training and technology which are a direct consequence of the continued (and increasing) reluctance to proactively and intrusively investigate sites.

18. It is not just the chemical make up of the water/sediment which is important in deciding which system of in situ preservation/storage to use, but also tidal regimes, sediment loading/erosion regimes, possible damage by fishing/boat traffic/divers, bottom sediments/geology etc. it is often these factors that will mean each site needs a different approach.

19. Needs to be determined on a case by case basis; sites like Wasa and Mary Rose etc. are sufficiently significant to merit the time/cost factor, most sites are not. It's important to try to maintain the conservation equilibrium that a site had prior to disturbance, but I'm not confident that it can be done adequately.

20. 1. The whole question of disposal of cultural material by any means needs reviewing dispassionately, reburial is just one of those. 2. In-situ preservation has been used as a way for governments to avoid their responsibilities, particularly the UK agencies. 3. When you can't tell the difference between in-situ preservation and neglect then its actually just neglect, see most of the UK 'protected' wrecks for details.

21. With conservation science advancing so rapidly, it is important to leave sites until we have a better understanding of how to deal with them. Financial restrictions aside, we can still study and enjoy the resources, left in situ, for many years into the future. Gaining knowledge from the sites is one of the most important aspects of leaving sites in situ.

22. If a site is buried in a cool, dark, anaerobic, non-fluctuating environment, and if there are no impending risks to the site, it stands the best chance on long-term preservation and naturally it should be left untouched.
23. I have worked on complete shipwreck excavation/recovery. I think it is always important to have the option of limited or larger-scale excavation for pure research purposes or to mitigate a threatened site, but often the best option is limited excavation/investigation with regular site monitoring to keep an assessment on in situ preservation.

24. In situ preservation needs regular monitoring of the site.

25. On certain sites I am familiar with, the question is often one of managed exposure and erosion rather than in situ preservation - the word is in itself misleading. On several sites, some areas were stabilised while others could not be. This has the disadvantage of limiting access to the visible sites which has serious management/community access ramifications. So each site HAS to be looked at on an individual basis, but also within a limited budget which means sites must be weighed against each other. In addition the simple issue of appropriately qualified practitioners available is a limiting factor with many sites.

26. I think the archaeological profession needs to make the important distinction that in situ preservation is NOT a 'do-nothing' approach (a commonly held belief among policy makers).

27. Start again with your survey and ask the question why the practitioner used the methods they did. Every site and every square mile of seabed is different, tides and coastal conditions control any attempt to conserve in situ.

28. Our institution is not working with the government concerned and I have no idea if the wreck reburial site has ever been monitored.

29. My comments reflect work on many different sites, in a whole range of environments, not one specifically, so are somewhat general.

30. There is wide-spread confusion among members of the professional community, as well as among the public regarding in-situ preservation and storage. This is intentional among some segments of the salvage/treasure-hunting groups to justify the 'marine peril’ argument that furthers their chances of success in obtaining salvage awards. The truth is, there is not enough basic science that has been done to know enough about the conditions that impact the preservation of waterlogged cultural resource after reburial. Everyone wants to have a quick fix to problems that currently plague submerged cultural resource management. The quick fixes are often not based in hard science, but are simply anecdotal. In my view, an archaeological site is not the best medium for developing the scientific data necessary to further the field. This is because of the differing wreck formation processes, which are often unique to the individual sites. There are often too many variables to isolate when attempting to analyze the environmental and deterioration data collected on these sites. Basic controlled science experiments are needed to isolate specific variables inherent in the wreck formation and wreck stabilization processes. Only from the rigorous analysis of the data will archaeologists and cultural resource management personnel be able to achieve an understanding of how to best protect these sites.

31. Over the past few decades, maritime archaeology has developed from an object-related profession into one where we talk about ‘Underwater Cultural Heritage’; a non-renewable resource that provides a unique opportunity to investigate and learn from our past. Shipwrecks are essentially closed finds. Their informative strength is the assemblage value of all the associated objects; ship, inventory, personal belongings and cargo collectively. Every shipwreck (every maritime archaeological site) has its own story to tell. This maritime archaeological resource has to be managed in a responsible and sustainable manner. Management means that sites – or information from these sites - must being secured over a long period of time. Sites have to be investigated according to international standards like the Annex of the UNESCO 2001 Convention for the Protection of the Underwater Cultural Heritage and more and more sites are also being protected in situ. Archaeologists, conservators and policy-makers are now all involved in the management of Underwater Cultural Heritage. The in situ protection of sites is an integrated part of this management process. Recent international standards state that in-situ preservation is the first option to be considered when managing a site. Not the 'best' option, as some would have us believe, but the 'first' option. If there is
good reason to intrusively investigate a site, then that may be a viable option. In situ preservation is simply one tool in the archaeologist’s armoury, albeit an important and useful one.

32. I’m getting the sense that you are not researching underwater exhibition/storage for the developing area of underwater museums. In deep water coastal archaeology it will develop and present new ethical, security and technical problems for conservators etc. Google Monterey Bay, bird-on-a-wire technology for mat. sci applications.

33. Contact institution’s conservators

34. In situ preservation is one of many options. However if it is used as a blanket policy it is wrong. Without excavation we learn nothing, either archaeological, historical or technological. Leaving it to the future is a cop out. Unless you excavate you will never find out how to properly preserve waterlogged material

35. In situ preservation is a preferred initial option. Site disturbance is only justified within well planned research parameters, including adequate funding prior to disturbance - and only with appropriate authorisation.

36. No reburials have been undertaken; work restricted to in situ recording and then covering of site.
Part C

C1. Regardless of whether or not *in situ* preservation or storage was used, do you or your organisation have a site monitoring plan to site(s) you have investigated?

<table>
<thead>
<tr>
<th>C1</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>62</td>
<td>69.7%</td>
</tr>
<tr>
<td>No</td>
<td>19</td>
<td>21.3%</td>
</tr>
<tr>
<td>No Response</td>
<td>8</td>
<td>9.0%</td>
</tr>
<tr>
<td>Total</td>
<td>89</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
C2. If you do monitor sites, do you have a formal schedule for this work?

<table>
<thead>
<tr>
<th></th>
<th>C2</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>13</td>
<td></td>
<td>18.6%</td>
</tr>
<tr>
<td>No</td>
<td>46</td>
<td></td>
<td>65.7%</td>
</tr>
<tr>
<td>No Response</td>
<td>11</td>
<td></td>
<td>15.7%</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td></td>
<td>100.0%</td>
</tr>
</tbody>
</table>

If yes, how is it scheduled and what procedures does it entail?

1. I find difficult to answer this question, as the actual monitoring is conducted by professional marine archaeologists working for the concerned institution.
2. Quarterly visits to site, using total station to monitor sediment changes over time.
3. Regular inspections and taking profiles across sites, though some organisations I worked for didn’t monitor.
4. Viewing tide tables barometer stage of moon weather conditions aerial observation.
5. We do try to a regular interval based on availability of personnel and weather.
6. It depends on the site; some are formally monitored while most are not.
7. It varies from site to site, but for the most part, monitoring is based on site condition and frequency and amount of site visitation.
8. We have formally attempted to schedule up to 5 days per month monitoring sites, though in reality this schedule is indeed dependent on factors such as those listed above.
9. This varies form site to site - often it involved visual inspection of sediment levels against markers at different points around the site, as well as redrawing of survey plans and monitoring of wood. On particular sites, monitoring devices are placed on them for particular periods (water and current monitoring etc).
10. In a way however we do. However, politically we are struggling to get enough funding and willingness to monitor in such a way.
11. We deployed 1-year duration dataloggers for open-water-at-wrecksite annual monitoring (currents, temperature, salinity, internal waves). We also deployed material analog decay experiments (coupons arrayed as racks in open water and as spikes in sediment to compare open water to subsurface decay expressions).
12. There is a schedule for the one wreck. Conservation staff have visited the site to attempt to inspect. Other sites depend on finance, and that is never guaranteed into the future.
13. 2 times a year.
### C3. Why do you monitor the site(s)?

<table>
<thead>
<tr>
<th>C3</th>
<th>Responses</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>To ensure the integrity of the site and for updating necessary site plans</td>
<td>40</td>
<td>44.0%</td>
<td>66.7%</td>
</tr>
<tr>
<td>To ensure the integrity of the site and monitor in situ preservation or storage</td>
<td>36</td>
<td>39.6%</td>
<td>60.0%</td>
</tr>
<tr>
<td>Other</td>
<td>15</td>
<td>16.5%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Total</td>
<td>91</td>
<td>100.0%</td>
<td>151.7%</td>
</tr>
</tbody>
</table>

**Responses to “Other”**

1. Department of Materials Conservation and Department of Maritime Archaeology research programme
2. Combination of both along with cleaning of interpretive plaques
3. To monitor stability of site
4. To better understand in-situ processes
5. Reporting state of environment, collect newly exposed materials where appropriate
6. To see whether conditions are suitable for diving on the 110 recorded sailing wrecks on our 100 kilometre beach
7. Establish dynamic levels of the environment, especially sand movement
8. Sometimes under the terms of cooperative agreements to check for vandalism.
9. Your wording needs work - you cannot 'ensure the integrity of the site', merely record its demise
10. Our mandate as an agency is in situ preservation of sites for visitors now and for years to come. We monitor sites to accomplish that mandate.

11. To seek out sedimentation patterns, to prevent looting or provide warning signs of such activity and others including storm action, beach replenishment dredging, etc.
12. To ensure the integrity of the site, and to plan interventions as required
13. To address the suitability of the wrecksite as an underwater museum
14. To collect data for developing improved storage/preservation methods
15. In an ideal world to provide for updating of plan
C4. What types of monitoring do you use on the site(s)? Check all that apply.

<table>
<thead>
<tr>
<th>C4</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Visual monitoring, including photography, videography and notes</td>
<td>59</td>
</tr>
<tr>
<td>Materials sampling and analysis</td>
<td>24</td>
</tr>
<tr>
<td>Sediment sampling and analysis</td>
<td>21</td>
</tr>
<tr>
<td>Corrosion measurements</td>
<td>27</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>137</td>
</tr>
</tbody>
</table>

Responses to “Other”
1. Sediment depth monitoring
2. Restricted navigation zone
3. Side Scan sonar imagery. The visibility in our area generally precludes video/photography.
4. Most often it is visual monitoring
5. Data logger, multibeam
6. Long-term materials decay testing
C5. What types of equipment do you use during your monitoring? Check all that apply.

<table>
<thead>
<tr>
<th>C5</th>
<th>Responses</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cameras and/or video equipment</td>
<td>52</td>
<td>50.5%</td>
<td>88.1%</td>
</tr>
<tr>
<td>Dipwells, <em>in situ</em> sampling and subsequent analysis</td>
<td>15</td>
<td>24.6%</td>
<td>25.4%</td>
</tr>
<tr>
<td>Electrodes, <em>in situ</em> sampling and subsequent analysis</td>
<td>26</td>
<td>25.2%</td>
<td>44.1%</td>
</tr>
<tr>
<td>None</td>
<td>3</td>
<td>2.9%</td>
<td>5.1%</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td>6.8%</td>
<td>11.9%</td>
</tr>
<tr>
<td>Total</td>
<td>103</td>
<td>100.0%</td>
<td>174.6%</td>
</tr>
</tbody>
</table>

Responses to “Other”
1. Total station, sediment cores
2. Visual inspection and measurements taken at control points around site
3. Plastic rules
4. A number of other types of analysis and monitoring
5. Side scan sonar, and also attempts have been made (not always successful) to install and monitor graduated poles to measure sand movement

6. Multibeam
7. Data loggers
C6. Do you have monitoring equipment set up on site permanently?

<table>
<thead>
<tr>
<th>C6</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent On Site Monitoring Equipment</td>
<td>5</td>
<td>7.1%</td>
<td>7.1%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Single Use On Site Monitoring Equipment</td>
<td>37</td>
<td>52.9%</td>
<td>52.9%</td>
<td>60.0%</td>
</tr>
<tr>
<td>Samples Collected and Analysed Off Site</td>
<td>17</td>
<td>24.3%</td>
<td>24.3%</td>
<td>84.3%</td>
</tr>
<tr>
<td>No Response</td>
<td>11</td>
<td>15.7%</td>
<td>15.7%</td>
<td>100.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>70</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>100.0%</strong></td>
<td></td>
</tr>
</tbody>
</table>
C7. Are there any changes you would make to you current site monitoring processes? Explain briefly.

1. Not currently
2. We would like to make use of on site equipment to keep continual measurements of sediment changes, exposure etc. Unfortunately costs, expertise and available equipment are prohibitive
3. More monitoring involving larger groups of avocational diving clubs
4. We should be monitoring ph, etc. but do not have staff.
5. Yes, I would like to install current and water temp etc monitoring equipment permanently
6. We would employ multi-beam sonar if we could afford it.
7. No
8. Formalise and undertake more regular monitoring - but constrained through lack of finances
9. We are currently undertaking a corrosion project which involves leaving introduced samples on site for a period of time, before removing and analysing them in the laboratory.
10. If time, funds, staff and organisation allowed, there is scope to ensure that the system of site monitoring is more systematic than at present, with better recording systems.
11. Since these responses address numbers of sites, there are variations; one site had equipment left in situ for months, others are tested with single use and still others have collection for analyses elsewhere; one answer does not fit all situations. My region is hampered by near zero visibility at all times so photography is extremely limited and this limits many forms of monitoring.
12. It would be great to be able to record more and more often so we can record the destruction more accurately
13. Not at this time. Financially and practically, our current monitoring process is effective and efficient.
14. We would like to eventually re-install poles to measure sand movement as mentioned before; though our sites are dynamic enough to make this problematic (poles disappear or get dislocated). More effort can be made for more regular monitoring visits, though the number of sites and duties in the office are always challenging.
15. They vary from site to site.
16. Methodology would be slightly different and more environmental parameters would be included in the study.
17. Yes, it would be a more formal planned process
18. Next time use Hypnos sampler for redox measurement.
19. I have not been in the department for some years when I became Director of the museum. Since then I have been writing books. The site monitoring is carried out primarily by the Conservation staff. The biggest challenge is that all governments change, and during those changes funding for matters like regular monitoring comes under pressure.

20. Depending upon the site some parameters are ideally measured ex situ but others should be monitored for longer periods - the problem we have is obtaining funding for equipment.

21. No changes

22. A more formal and strict schedule is desired, but since that depends on personnel (often volunteers) and funds it is not possible at this time.
C8. If you or your organisation do not monitor sites, why? Check all that apply.

<table>
<thead>
<tr>
<th>C8</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Equipment and/or materials required in preservation process are difficult to access</td>
<td>6</td>
</tr>
<tr>
<td>Time constraints</td>
<td>11</td>
</tr>
<tr>
<td>Insufficient professional personnel available</td>
<td>9</td>
</tr>
<tr>
<td>Insufficient volunteer personnel</td>
<td>4</td>
</tr>
<tr>
<td>Insufficient training of current personnel and/or volunteers</td>
<td>4</td>
</tr>
<tr>
<td>Internal policies of organisation</td>
<td>6</td>
</tr>
<tr>
<td>Governmental legislation</td>
<td>1</td>
</tr>
<tr>
<td>Governmental/agency permitting difficulties</td>
<td>1</td>
</tr>
<tr>
<td>Financial</td>
<td>8</td>
</tr>
<tr>
<td>Didn’t believe it was necessary</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
</tr>
</tbody>
</table>

Responses to “Other”
1. Just now starting underwater program and training staff and obtaining survey data. Periodic and post storm monitoring will be in future plans.
2. Site to be buried under 3-4 m of dredge spoil.
3. The government employee avoided the issue
5. As a consulting/participating member of the project with no long-term ties, I can only suggest monitoring (which I would) but I have no control over whether or not it is carried out.
6. Sites are monitored on more or less ad hoc basis. Monitoring plans will be developed in the near future.
C9. What, if anything, would convince you or your organisation to monitor sites in the future? Check all that apply.

<table>
<thead>
<tr>
<th>C9</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better access to necessary equipment</td>
<td>9 N</td>
</tr>
<tr>
<td>and/or materials required for</td>
<td>12.3%</td>
</tr>
<tr>
<td>preservation process</td>
<td>52.9%</td>
</tr>
<tr>
<td>More time available for process</td>
<td>16.4%</td>
</tr>
<tr>
<td></td>
<td>70.6%</td>
</tr>
<tr>
<td>More professional personnel available</td>
<td>11.0%</td>
</tr>
<tr>
<td></td>
<td>47.1%</td>
</tr>
<tr>
<td>More volunteer personnel available</td>
<td>8.2%</td>
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<td></td>
<td>35.3%</td>
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<tr>
<td>Better training for professional</td>
<td>6.8%</td>
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<tr>
<td>and/or volunteer personnel</td>
<td>29.4%</td>
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<td>New or updated internal policies</td>
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<td>New or updated government legislation</td>
<td>5.5%</td>
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<td></td>
<td>23.5%</td>
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<td>Permitting system with less associated</td>
<td>4.1%</td>
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<td>difficulties</td>
<td>17.6%</td>
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<tr>
<td>More money available for projects</td>
<td>19.2%</td>
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<td></td>
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<tr>
<td>New research supporting the benefits of</td>
<td>8.2%</td>
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<td>in situ preservation/storage</td>
<td>35.3%</td>
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<tr>
<td>Nothing could convince me of its</td>
<td>0.0%</td>
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<tr>
<td>feasibility</td>
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<tr>
<td>Other</td>
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<td>5.9%</td>
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<td>Total</td>
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<td>429.4%</td>
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Responses to “Other”

1. I would and do recommend monitoring, but the nature of my work does not allow me to carry this out or force my clients to carry out the recommendation.
Please make any additional comments you feel are important about site monitoring in the space below.

1. Site monitoring is important to help observe deterioration rates, help preserve integrity from public visitors, and monitor biological life on the site.

2. Our organisation relies heavily on visual monitoring and diver reports. Funds and lack of personnel make frequent or in depth monitoring difficult.

3. We have several large WWII vehicles. Vandalism and safety are concerns. Monitoring could identify changes that might create safety hazards and require some action. Also, changing environmental conditions might expose additional material, such as unexploded ordnance, that would pose threat. We plan to include staff and volunteers to monitor the resources. We will train volunteers to become site stewards. Local divers and operators are stakeholders in the resources and have expressed desire to help preserve and protect the resources. An interpretive UW trail is planned. Monitoring will ensure that known resources (and visitors) are protected to the greatest extent possible.

4. Avocational divers with maritime archaeology trained methodologies should perform the monitoring and send reports to their resident maritime archaeologist, these reports should then be gathered a report made by archaeologist to government body of culture

5. Our biggest problem is lack of funding preventing sensible time on site and a limited equipment base and the fear of losing equipment left on site, which has happened in the past

6. I think monitoring is essential for managing archaeological sites.

7. If we had the time and money it would be a very beneficial exercise...

8. Site monitoring usually falls under the responsibility of state or federal agencies. Unless it is part of a contractual obligation with a client it is not usually considered.

9. It should be done more, but there's so little time and money.

10. As reburial becomes more common practice a standardised framework for collection management in situ will need to be established. This will encompass issues such as burying like with like, access and monitoring programs.

11. One of the main problems with site monitoring is the limits in terms of time and people that can be dedicated to fieldwork for site inspection/monitoring work. Even with two field seasons a year, some sections of coastline may not be visited for over 5-10 years, or more. We very much rely on contacts with local divers to alert us of changes in site stability.

12. Finances and personnel limit how much can realistically be done; as a program continues to find more and more sites, being able to monitor them all becomes increasingly difficult to impossible for all but the most important or most vulnerable, even when one has a sizeable and active volunteer contingent.

13. It should be encouraged, so we need some working standards that all agencies can adopt.

14. Management of the Department including the Director need convincing it is an issue by any current maritime archaeologist employed. Underwater = out of site out of mind

15. The involvement of volunteers groups is crucial on PWA sites - regular visits to so many sites by practitioners alone is not possible.
16. I suggest that you will get different answers from all who take part in this survey. Every site requires a different approach to in situ conservation. Hope this response is of some use to you.

17. 1. We used to have a site continuously monitored with a data logger; this proved to be too expensive and took much of labour. It did not give us that much more results than measuring from time to time. 2. (C2) We would like to arrange a monitoring strategy for all sites. In a way we have through the site management plans. However, we are still in the middle of a political fight to get enough funding to be able to execute an overall monitoring scheme. We claim for each site a strategy but it proofs to be extremely difficult to be able to go on site when we want to. 3. We however, monitor specific sites each year with especially the multibeam sonar.

18. Our institution fully excavates its sites and conserves everything. The one wreck was an exception.

19. it's a question of having the right people on the spot and on staff in a paid capacity - otherwise it's too ad hoc and data is unreliable - we have sponsored a PhD student to monitor sediment at the wreck and measure when pre-disturbance conditions inside the sediment are reached again and restored to pre-dist levels

20. To clarify... as a conservator in private practice who may be hired to carry out conservation within a specific time frame, I have no control over the actions of a client after my term of employment with them has concluded. I make suggestions for long term care, but it is up to the client as to whether or not they follow the recommendations.
References


De Vaus, D.A. 2002, Surveys in social research, 5th edn, Allen & Unwin, Routledge, St. Leonards, NSW.


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Hall, J.L. 2007, 'The Fig and the spade: countering the deceptions of treasure hunters', *AIA Archaeology Watch*.


Henderson, S. 1989, 'Biofouling and corrosion study' in Submerged cultural resource study: USS Arizona and Pearl Harbor National Historic Landmark, ed. D.J. Lenihan, National Park Services Submerged Cultural Resources Unit, Santa Fe, NM.


MacLeod, I.D. 1998a, 'In situ corrosion studies on iron shipwrecks and cannon: The impact of water depth and archaeological activities on corrosion rates', Metal 98: proceedings of the international conference on metals conservation, Draguignan-


Oxley, I. 1998a, 'The environment of historic shipwreck sites: a review of the preservation of materials, site formation and site environmental assessment', Master of Science, Geography and Geosciences, University of St Andrews.


