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The Protection of the
Underwater Cultural Heritage

UNIT 10

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Intrusive Techniques in Underwater Archaeology



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UNIT 10

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UNIT 10

Author Andrew J. Viduka

Intrusive Techniques in Underwater Archaeology

Core Knowledge of the Unit

This unit introduces students to intrusive techniques that can be used in underwater excavations. Students are provided with an ethical, regulatory and archaeological framework to understand when to use intrusive techniques on an archaeological site and what techniques are available.

On completion of the Intrusive Techniques in Underwater Archaeology unit students will:

- Understand that intrusive activities are destructive and should only be undertaken with clear archaeological justifications
- Be able to discuss the characteristics of underwater excavations
- Have knowledge of different intrusive techniques and be able to discuss their utility in various conditions on an archaeological site
- Have examined a range of case studies
- Understand the responsibilities of an archaeologist associated with an excavation

Introduction to the Unit

The overall aim of the 2001 UNESCO Convention is to encourage the responsible protection of underwater cultural heritage, with a special focus on *in situ* preservation as the first option to consider. The convention does not preclude excavation. In the Annex of the Convention a framework for project design, funding, conservation and site management are outlined so that when intrusive activities are undertaken a standard can be achieved that maximizes positive archaeological outcomes.

Intrusive techniques can be used in assessment, searching, sampling and excavation. These techniques require skill, knowledge and a thorough understanding of the implications of decisions in the short, medium and long term. Like survey, excavation should be taught and discussed because interventive techniques are the primary tool for archaeologists to uncover new information about the past.

Excavation is a part of the overall management of underwater cultural heritage. The Rules included in the Annex of the UNESCO Convention for the Protection of the Underwater Cultural Heritage (Paris 2001) state:

Rule 1. The protection of underwater cultural heritage through *in situ* preservation shall be considered as the first option. Accordingly, activities directed at underwater cultural heritage shall be authorized in a manner consistent with the protection of the heritage, and subject to that requirement may be authorized for the purpose of making a significant contribution to protection or knowledge or enhancement of underwater cultural heritage.

Rule 3. Activities directed at underwater cultural heritage shall not adversely affect the underwater cultural heritage more than is necessary for the objectives of the project.

Rule 4. Activities directed at underwater cultural heritage must use non-destructive techniques and survey methods in preference to recovery of objects. If excavation or recovery is necessary for the purpose of scientific studies or for the ultimate protection of the underwater cultural heritage, the methods and techniques used must be as non-destructive as possible and contribute to the preservation of the remains.

In the history of archaeology it is not difficult to find examples of excavations which have resulted in incomplete reports, sites not being actively managed post the excavation and recovered objects not being well cared for. Whatever the reasons for these outcomes, the results are the same, the loss of part or all of a site and its record for future interpretation and study.

The concept of *in situ* preservation as a first option is in part a response to indiscriminate or poorly conceived, planned, reported and budgeted for excavations. The Rules of the Annex aim to articulate a uniform framework for activities directed at underwater cultural heritage. These rules stipulate not only general principles on how activities should proceed, they also aim to have archaeologists prepare clear project designs and put in place appropriate levels of funding, conservation, site management and reporting outcomes as part of the initial project plan. The aim of this is to minimize the potential of sites not being correctly excavated and reported, while retaining the maximum archaeological information for the future, by effective ongoing post-excavation management and monitoring.

It is important to emphasize that while *in situ* preservation should be considered as the first option, it is not the only option. Excavation and other interventive techniques are vital tools for archaeologists to uncover new information about the past, in order to reconstruct past culture or life and to discover information that will assist in the management of the site. This unit emphasizes that interventive activities should only commence under the right circumstances and with the sound justifications, with the correct budget and framework in place.

1 Excavations: When do you Decide to Use Intrusive Techniques on an Archaeological Site?

Excavating on land is hard enough, but some people like to make things extra difficult for themselves, and working underwater is the archaeological equivalent of standing up in a hammock (*The Bluffer's Guide to Archaeology*, 2004, pp. 31).

As an archaeological site contains unique records of the past which the process of excavation will dismantle (and by so doing destroy), it is essential to understand that excavation can only be justified in certain circumstances. The archaeologist must have a clear understanding of the reasons for undertaking the excavation (be it rescue or for research purposes), an understanding of the techniques and methods that will be used, and the effects these techniques and methods will have on the archaeological record. If the excavation is solely for research purposes, then it is important that the archaeologist is clear on what research questions need to be answered by the excavation. Can these questions be answered differently? Is the excavation necessary? Only when questions such as these cannot be answered by other means, can an excavation be justified. Adequate budget, storage, conservation and work facilities, together with trained archaeological staff to handle the material, are absolutely essential before excavation can be considered (Green, 2004, pp. 235).

1.1 Underwater Excavation

This unit will explore the following aspects of an excavation:

- When to use intrusive techniques on an archaeological site
- Approaches to excavation
- Intrusive archaeological techniques
- Responsibilities of an archaeologist

Suggested Reading

- Baker, P. 1986. *Understanding Archaeological Excavation*. London, ISBN 0-7134-3632-8.
- Baker, P. 1977. *The Techniques of Archaeological Excavation*. London. ISBN 0-7134-2739-6.
- Bowens, A. (ed.). 2009. *Underwater Archaeology: The NAS Guide to Principles and Practice*, Second Edition. Nautical Archaeology Society. Blackwell, pp. 135-147.
- Green, J. 2004. *Maritime Archaeology A Technical Handbook*. Second Edition. Elsevier Academic Press, pp. 235.
- Underwood, C. 2011. *Excavation Planning and Logistics (HMS Swift 1770)*. *Oxford Handbook for Maritime Archaeology*. USA, Oxford University Press.

1.2 Responsibilities

By choosing to undertake an excavation, certain responsibilities are implicit on the archaeologists. Pre and post-excavation obligations are as important as on-site obligations. The Rules of the Annex of the UNESCO Convention for the Protection of the Underwater Cultural Heritage (Paris 2001) articulates the responsibilities that an archaeologist must embrace in relation to: project design (Rules: 9, 10, 11, 12, 13); preliminary work (Rules: 14, 15); project objective (Rule 16); methodology and technique; funding (Rules: 17, 18, 19); competence and qualifications of participants (Rules: 22, 23); conservation and site management (Rules: 24, 25); documentation (Rules: 26, 27); safety (Rule 28); environment (Rule 29); reporting (Rules: 30, 31); curation of project archives (Rules: 32, 33, 34); and dissemination (Rules: 35, 36).

Suggested Reading

- UNESCO. 2001. *Convention on the Protection of the Underwater Cultural Heritage*. Paris.
- Bowens, A. (ed.). 2009. *Underwater Archaeology: The NAS Guide to Principles and Practice*, Second Edition. Nautical Archaeology Society. Blackwell, pp. 45.

1.3 Pre-disturbance Surveys

Pre-disturbance surveys are always carried out prior to excavation. A primary rationale for a pre-disturbance survey is to understand the archaeological significance of a site. Pre-disturbance surveys also enable an understanding of the area of the site, depth of overburden, site's condition, extent and material types of the archaeological assemblage (Richards, 2001).

1.4 Test Pits: Exploratory Trenches

A pre-disturbance survey may be followed by an exploratory excavation of a (1 m x 1 m or larger) test pit/trench to confirm the extent of site, depth and material variety of the archaeological deposit. These test pits can be at specific locations such as the bow, stern or even in the midships section, thus enabling the excavation to use the structure as a guide, rather than an arbitrary grid system. This information forms the basis for planning a more comprehensive excavation strategically and from an operational perspective, i.e. how long the work will take, storage and conservation facilities required and budget implications (Atkinson and Nash, 1991).

Suggested Reading

- Atkinson, J. and Nash, M. 1991. *Report on the Excavation of the Hadda*. *Australian Institute of Maritime Archaeology*. 11.2, pp. 17-24.

1.5 Practical Approaches to Excavation

Green (2004, pp. 237) states that there are two simple approaches to excavation. One is to excavate over large areas of the site, layer by layer and the other is to work the site in small sections (either grid or trenches), layer by layer, repeating section by section across the site. While Green's statement could imply that the whole site will invariably be excavated, it is more common today that the latter technique is used in small areas only, to answer concise research questions. *Mary Rose*, *Vasa*, *La Belle* and *Batavia* type excavations are increasingly rare. For example, in the Netherlands, trenches are generally first made around the bow and stern areas of the wreck, then near the middle of the wreck (as near to the main mast step as possible), as part of an extended assessment and/or before excavating the rest of the wreck. This utilizes the pre-disturbance model and provides the potential for being able to escalate it into a full blown excavation if required. Underwood (2011, pers. comm.) feels that there is a third option available for excavation when sediments are so sufficiently compacted that they do not slump. This third option involves beginning excavations with a small trench and then working, layer by layer, to reveal the stratigraphy of the site. This is followed by working in elevation, rather than as a 'plan view' excavation.

Today, time and budget constraints are everyday realities that require detailed planning to maximize restricted opportunities in the available excavation time. This fiscal reality lends itself to the excavation of small areas to address concise questions. Smaller trenches also have the major benefit of leaving the majority of the archaeological deposit undisturbed, as a control for the future study. See *Additional Information 1*.

ADDITIONAL INFORMATION

1 The Australian Heritage Shipwreck Protection Project commencing in April 2012, is an example of a multi-disciplinary research driven excavation of a shipwreck site. The project addresses research questions on early ship construction in Australia, site formation, developing preservation strategies, reburial, data management and policy guideline development. In conjunction with these clearly articulated research questions, the project has been meticulously budgeted and planned prior to initiating excavation activities. See: www.ahspp.org.au (Accessed March 2012)..

Suggested Reading

- Bowens, A. (ed.). 2009. *Underwater Archaeology: The NAS Guide to Principles and Practice*, Second Edition. Nautical Archaeology Society. Blackwell, pp.125.
- Green, J. 2004. *Maritime Archaeology: A Technical Handbook*, Second Edition. Elsevier Academic Press, pp. 237-244.

1.6 Grid Systems

Grid systems can be rigid, such as metal scaffolding, or less rigid, such as plastic or rope. They can cover the entire site or comprise of smaller sections that can be moved around. All have the same purpose; to divide the site into areas which provide orientation and defined sectors. On sites where construction is left, the construction may be the main feature to define work areas. Recording where the grids are is very important. Logistically, gridding smaller areas is much simpler and less vulnerable, than the time consuming and expensive total grid system.

Green (2004, pp. 238) states that the use of a particular grid system on a given site needs careful consideration. There are both advantages and disadvantages to rigid and non-rigid systems dependant on environment, construction, staff experience and the knowledge of the site.

1.6.1 Rigid Grid Frames

Rigid grid frames are used on many excavations, including that of the *James Matthews* and *HMS Pandora*.

Grids are usually accurately surveyed into the site plan and the location of loose finds and fragments are approximately recorded inside the grid. The location of more important objects and structures are generally more accurately recorded.



Image of a rigid grid system used on the *James Matthews*. Here, a diver is recording the hull alongside part of the cargo of roofing slates. © Jeremy Green

Advantages of rigid grids:

- They give orientation to the site and defined work areas, which is particularly helpful in low visibility.
- Offer support for the excavators to avoid disturbing the site and mitigate against potential poor buoyancy control of divers.

Disadvantages of rigid grids:

- Rigid grid frames can potentially damage artefacts, although sandbags placed beneath the 'feet' of the grid can help to reduce the impact of the weight of the grid.
- Are expensive to construct, install and maintain.
- The grid frame's legs can be affected by the removal of sediment during the excavation and from scour action on sites where there are strong currents.
- Very vulnerable to being moved or damaged by fishing or dredging activity and can be bumped by divers. Unless the grid frame is completely immobile, inaccuracies are likely to occur in the survey result. If this happens and the grid is the basis of the site survey, this will almost certainly negate the previous results. Valuable dive time will then be taken up having to reconstruct and reinstall the grid itself.
- Green (2004, pp. 241) notes that rigid grids frames can cause practical difficulties during excavation and recommends the use of large 4 m² grids to offset potential problems.

1.6.2 Non-Rigid Grid System

An alternative to the rigid grid frame is the non-rigid system which is also plotted into the site plan. A series of parallel lines or bars are laid across the site. The lines marking the grid can be scaled so that its relative position can be determined. George Bass used string grid lines on the *Tektas Burnu* site in Turkey.



A non-rigid grid system in use at the *Tektas Burnu* site in Turkey. © Jeremy Green

Advantages of non-rigid grids:

- An experienced team can excavate quickly and efficiently
- Green (2004, pp. 243) states that complex structures can be excavated in one piece, i.e. grid lines can be adjusted easily to enable excavation of an entire feature
- A bar or tape can be used to keep the excavation moving across the site
- Easy to backfill into a previously excavated trench
- A good method for sites with little vertical structure (Green, 2004, pp. 243-244)

Disadvantages of non-rigid grids:

- The whole site is never shown completely excavated (although a section by section photo mosaic can still be produced)
- Positioning the non-rigid grid system and connecting them all together is likely to be more difficult
- Recording locations accurately during the excavation is more difficult
- More difficult to control excavation without frames

1.6.3 Excavating Without a Grid (Due to Poor Environmental Conditions)

On sites in the surf zone or where there are strong underwater currents or intense wave action, the use of grids of any type is much more difficult. Some sites are also prone to fishing or nearby dredging activity, which could damage or move the grid. The additional time required to regularly replace or reconstruct due to these factors, makes the use of a grid impractical and costly.

In such conditions, it is likely that the main guide or reference for the excavators is the wreck itself. Consideration can be given to using known points on the structure to guide the excavation. Control points can be placed on the structure itself or depending on the substrate, poles can be placed in the seabed around the site. Temporary baselines can also be positioned between control points to guide the work.

1.7 Caissons and Cofferdams

Caissons and/or cofferdams are watertight structures generally used in shallow waters, that come in a range of formats; from large scale and sophisticated double walled interlocking metal 'sheets' with compacted sand fill between each wall, such as that used in the excavation of *La Belle* (Bruseh and Turner 2005), to single rigid plastic or metal systems, such as those used on the Skuldelev ships excavations in Denmark (Crumlin-Pederson and Olsen, 2002, pp. 34). Caissons come in smaller arrangements such as a small 44 gallon drum (Green, 2004, pp. 243) or the soft sided Pochin enclosure system. Caissons can also be sealed at the top. Most, if not all, cofferdams and caissons so far used in archaeology have been open to the air systems. They have generally employed where visibility was going to be a serious issue or where significant cost reduction and other efficiencies could be created by excavating on dryer land.

In large scale caisson/cofferdams, the area around the site is made water proof through the insertion of barriers into the sea or riverbed, which completely contain the site. Once contained, the water over the site is removed, allowing for excavation *à la* terrestrial archaeology.



A Pochin enclosure system, Hamble River.
© Charles Pochin



An earlier version of an enclosure system. A diver uses a water dredge and utilizes the floating 'grid' for support while excavating.
© Charles Pochin

However, the use of cofferdams does not necessarily mean that water is precluded. In the case of the Yorktown shipwreck, a cofferdam was placed in 7 metres of water, surrounding the site. The rationale for the cofferdam was as a means for improving conditions of the excavation, as the site was located in Yorke River, Virginia and was subject to strong currents and near zero visibility. By using this system, water inside the enclosure could be filtered and clarified to improve working conditions (Broadwater, 1985, pp. 301-303).

In the case of the Skuldelev ships, where a cofferdam was built around an area of approximately 2,500 m² (Crumlin-Pederson and Olsen, 2002, pp. 30), water was not removed immediately from inside the cofferdam walls, but was lowered gradually in line with excavation of the site. The rationale for the gradual reduction was to minimize any increased weight by ballast stones on the deteriorated timbers (Crumlin-Pederson and Olsen, 2002, pp. 33). In the case of the *La Belle*, the water was removed completely from the cofferdam to facilitate excavation.

Another variation currently being used in Piraeus Harbour by the Zea Harbour Project, is the Pochin enclosure system. This system incorporates inflated pontoons with a continuous solid but flexible sheet of plastic that can be attached to the seafloor. This soft caisson system, when used in relatively calm waters, enables greater clarity in turbid waters, as sediment can settle to the bottom through reduced agitation in the water column.



Clear water enclosure system being used by the Zea Harbour Project.
© Bjorn Loven

Advantages of the dry caisson system:

- Archaeological processes are not constrained by dive time limitations and dependency on diving logistics
- A range of non-diving specialists can be involved in the fieldwork
- It is possible to make careful records of the different layers excavated
- Ability to get very good visual documentation
- Ideal in shallow sites where excavation must proceed quickly, i.e. rescue archaeology
- Budgeting for excavations and time management become significantly easier, as weather dependency and environmental/visibility issues are removed
- Containment walls can be rented and their installation and deconstruction can be included as a known fixed cost
- Research driven excavations can look for corporate sponsorship, as the infrastructure will be eye-catching and newsworthy
- As with the Skuldelev excavation, public access for non-divers can be included as a significant feature of the excavation

Disadvantages of the dry caisson system:

- Very significant setup and breakdown costs (*La Belle's* cofferdam cost US\$1.5 million in 1996). Note that the archaeological excavation does not really need to own the sheet piling and the material is re-useable. Expenses are associated with setup, breakdown and rental of capital equipment. Furthermore, unlimited access may well make the process cost efficient in particular circumstances, such as large scale excavations or rescue excavations which need to be conducted rapidly, due to development pressures.
- Need for a near continuous spraying program to stop the exposed material drying out. There are potential issues associated with spraying and the health of workers, as noted on the Skuldelev excavation.
- Limited to relatively shallow waters.
- Excavations must be undertaken carefully as archaeologists must try to not damage material while working.
- Cofferdams can usually only be effectively used for dry pumping when they can be founded upon an impenetrable layer of sediment.

Suggested Reading

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- Bruseth, J. E., Turner, T. S. 2005. *From a Watery Grave: The Discovery and Excavation of La Salle's Shipwreck, La Belle*. College Station, Texas A&M University Press. ISBN 1585444316.
- Crumlin-Pedersen, O. and Olsen, O. (eds.). 2002. *The Skuldelev Ships I. Topography, Archaeology, History, Conservation and Display, Ships & Boats of the North*, Vol. 4.1, pp. 30.
- Green, J. 2004. *Maritime Archaeology: A Technical Handbook*, Second Edition. Elsevier Academic Press, pp. 243.

2 Intrusive Techniques

2.1 Probing

Probing is a physical attempt to locate structures beneath the surface layers and is usually carried out in a systematic manner (along a line at fixed distances), to understand the extent of a site and depth of burial. The results of a probing survey are dependent on feel and are difficult to accurately measure.

Prior to the introduction of non-destructive remote sensing techniques, such as sub-bottom profiling, (which does not disturb the archaeological layers), probing was used because it is a simple and relatively effective technique. However, today the technique should be used with caution, due to the potential of damaging artefacts. The inclusion of this intrusive technique in this unit reflects the fact that the Foundation Course caters to a wide range of students, with differing access to remote sensing equipment, and recognizes that in certain circumstances the method remains a useful tool. Two broad questions that can be answered by careful use of this technique are: at what depth is the structure? And where does the site structure stop and start?

2.1.1 Solid Rod Probing

Solid rod probing requires a rod that is thick enough to not bend and thin enough to be able to be pushed into the sediment. Due to the limitations of this method, even when people are being careful, solid rod probing has been known to cause damage to objects.

2.1.2 Water and Air Probes

Water probes consist of a narrow hollow tube, down which low pressure water or air can be pumped. Water and air probes are capable of penetrating sediments more readily than a solid rod and can, in the case of water probes in particular, easily damage organic archaeological material. The aim is to feel contact with an object. Green (2004, pp. 259) notes that experienced users can detect the difference between pottery, wood or metal, through the sound of the contact.

By using this method, oxygen rich air or water is introduced into anaerobic environments which accelerates deterioration in that location for a period of time (dependant on depth, size, shape, composition of the overburden). New South Wales Heritage conducted a water probe survey when searching for the *Hive* shipwreck and their observations regarding the efficacy of the system provide an interesting insight into the technique (Smith, 1995).



Water probe in operation on the *Hive* site, Australia.
© Andrew Viduka

Suggested Reading

- Bowens, A. (ed.). 2009. *Underwater Archaeology: The NAS Guide to Principles and Practice*, Second Edition. Nautical Archaeology Society. Blackwell, pp. 135-139.
- Green, J. 2004. *Maritime Archaeology: A Technical Handbook*, Second Edition. Elsevier Academic Press, pp. 259.
- Smith, T. 1995. Probe Surveys of 'Dry' Shipwrecks. *Bulletin of the Australasian Institute for Maritime Archaeology*. 19.1, pp. 19-22.
- Watts Jnr, G.P. 1976. Hydraulic Probing: One Solution to Overburden and Environment. *IJNA* 5.4, pp. 76-81.

2.2 Taking Samples

A sample is a representative amount of material that has been collected from an archaeological or natural context (Bowens, 2009, pp. 139).

Samples are collected for a range of reasons, though usually for material identification of artefacts (Peters, 1996), dating, environmental analysis (biofacts) (Gorham and Bryant, 2007) and comparative background assessment, such as typological analysis.

Like any excavation, the sampling process requires its own plan prior to collection (Gorham and Bryant, 2007). Sampling requires a defined set of objectives that outline what is being sampled and why, so that a plan can be developed. These objectives will form a basis for the sample analysis and the selection of the analytical analysis technique to be used. For example, a metal artefact can be sampled for its metallurgical or chemical composition. Both methods require a physical sample to be collected, however, the sample size is different and preparation processes also vary. Chemical analysis is not only used to identify the parent metal composition for comparative analysis. It may also be used to ascertain the compounds formed on the deteriorated object's surface, which can assist in conservation. Consequently, a clearly defined sampling plan document is vital. No excavation should be undertaken without a detailed sampling plan and either the capacity to undertake the necessary analysis or to store the samples for future study.

2.2.1 Types of Sampling

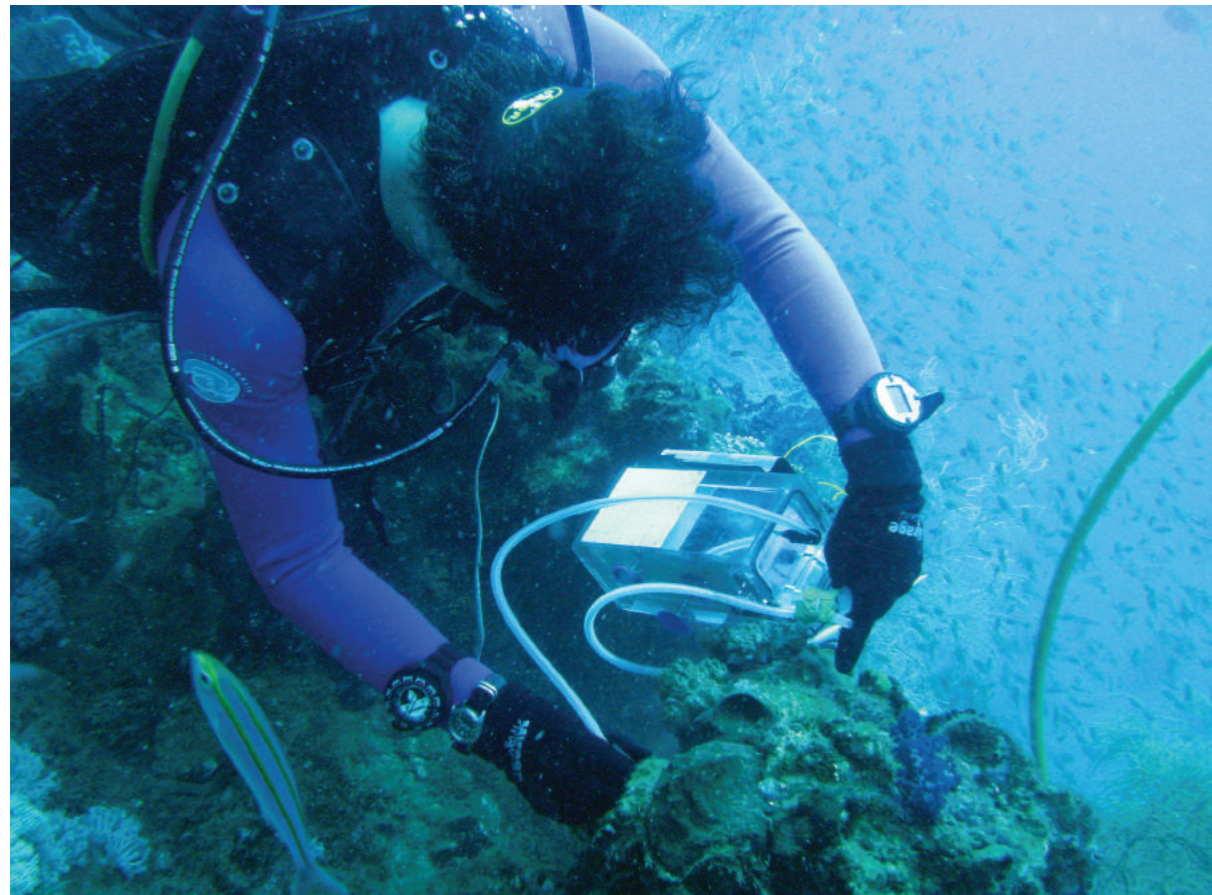
On-site sampling can be broadly broken down into environmental and artefactual material. A limited selection of objects can be collected as samples for identification, analysis or dating purposes. Sampling also continues once objects are recovered and are in conservation. Recovered objects often contain contents (Peters, 1996) or are themselves sampled and materially analysed (Viduka and Ness, 2004).

On-site environmental sampling aims to give an indication of everything natural or that, that has been introduced into the site by human activity, as well as the actual physical formation processes (stratigraphic, climatic, environmental or ecological data), prevailing on or near the site. Sampling is also used to understand the preservation values of the site (Oxley, 1998; Richards, 2001; Oxley and Gregory, 2002; Jensen and Gregory, 2006) and to obtain dates (Manders *et al*, 2009).

In situ sampling normally takes three forms: spot, core and column.

Spot sampling: refers to small sample sizes. There are numerous publications which refer to the actual methodology, including those by Bowens, 2009 and Gorham and Bryant, 2001. For example, underwater wood spot samples are collected for dendrochronology, to undertake dating and/or for timber analysis with which to answer questions regarding ship construction. Samples are most easily collected by sawing a portion of wood that contains a significant residual core of solid timber for analysis. Wood exposed to an aerobic environment and/or located near the surface or ends of timber pieces, is more likely to be deteriorated from a combination of hydrolysis, bacteria or marine borers. If possible, it is better to select a sample from a piece of structural timber and/or from a larger piece of timber that has been partially or wholly buried.

Diver collecting corrosion potential measurements. © Queensland Museum



Core sampling: produces a cylindrical section of whatever is sampled. Due to the huge variety of mediums to be sampled, there are a large range of different coring units and techniques, including the hand held auger. The physical make up of the medium helps identify the technique to be used and core size to be collected. Common techniques of coring include, but are not limited to: vibracoring, gravity coring drilling and rotary side wall coring.

Columns: (or monoliths) involve containers being pushed into sediment. This method requires good profiles to avoid contamination and achieve accuracy. It is a sampling technique used more often on terrestrial sites, than maritime.

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- Bowens, A. (ed.). 2009. *Underwater Archaeology: The NAS Guide to Principles and Practice*, Second Edition. Nautical Archaeology Society. Blackwell, pp. 136-140.
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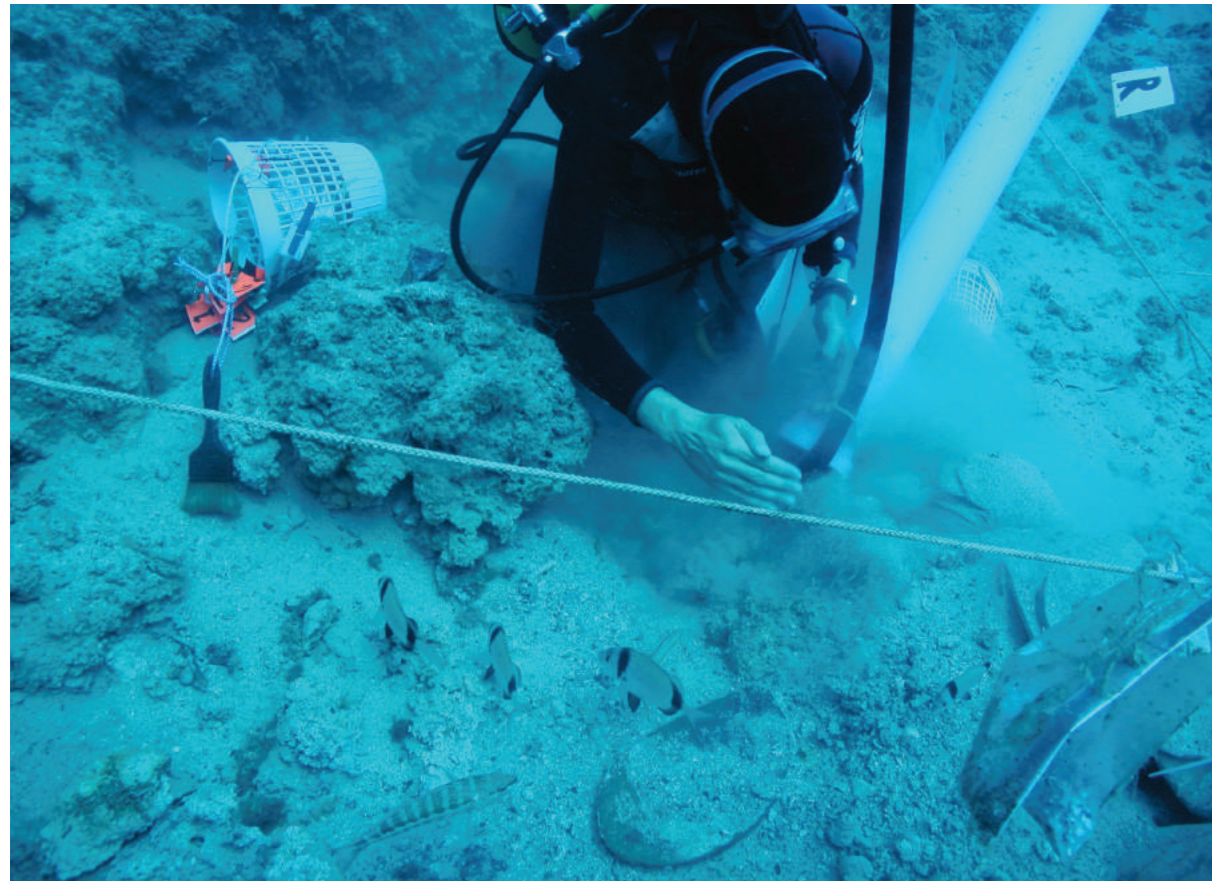
Divers collecting core sample on the Clarence site, Australia. © Andrew Viduka



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- Viduka, A. and Ness, S. 2004. Analysis of Some Copper-alloy Items from HMAV *Bounty* Wrecked at Pitcairn Island in 1790. METAL 2004. *Proceedings of the International Conference on Metals Conservation, Canberra Australia, 4-8 October 2004*. National Museum of Australia Publishers, pp. 160-172. ISBN 1-876944-33-1.

2.3 Loosening or Removing Sediment

The choice of tool to excavate a site depends on the nature of the sediments covering a site, and the condition and material type of objects being excavated. Since the aim of archaeological excavation is to meticulously excavate and document artefacts, the need to rapidly remove sediment (other than sterile overburden) is not a primary concern. As a very experienced maritime archaeologist, Christopher Underwood feels that the hand is the most sensitive excavation tool. Hand fanning in conjunction with a water dredge or airlift, enables the controlled removal of many sediments that would cover a site. Apart from in very cold water (less than 10 degrees), the hand should be un-gloved. For example, on the excavation of the HMS *Swift* in Argentina, archaeologists tended to wear gloves with the fingers cut off to provide the sensitivity that is needed in most situations.



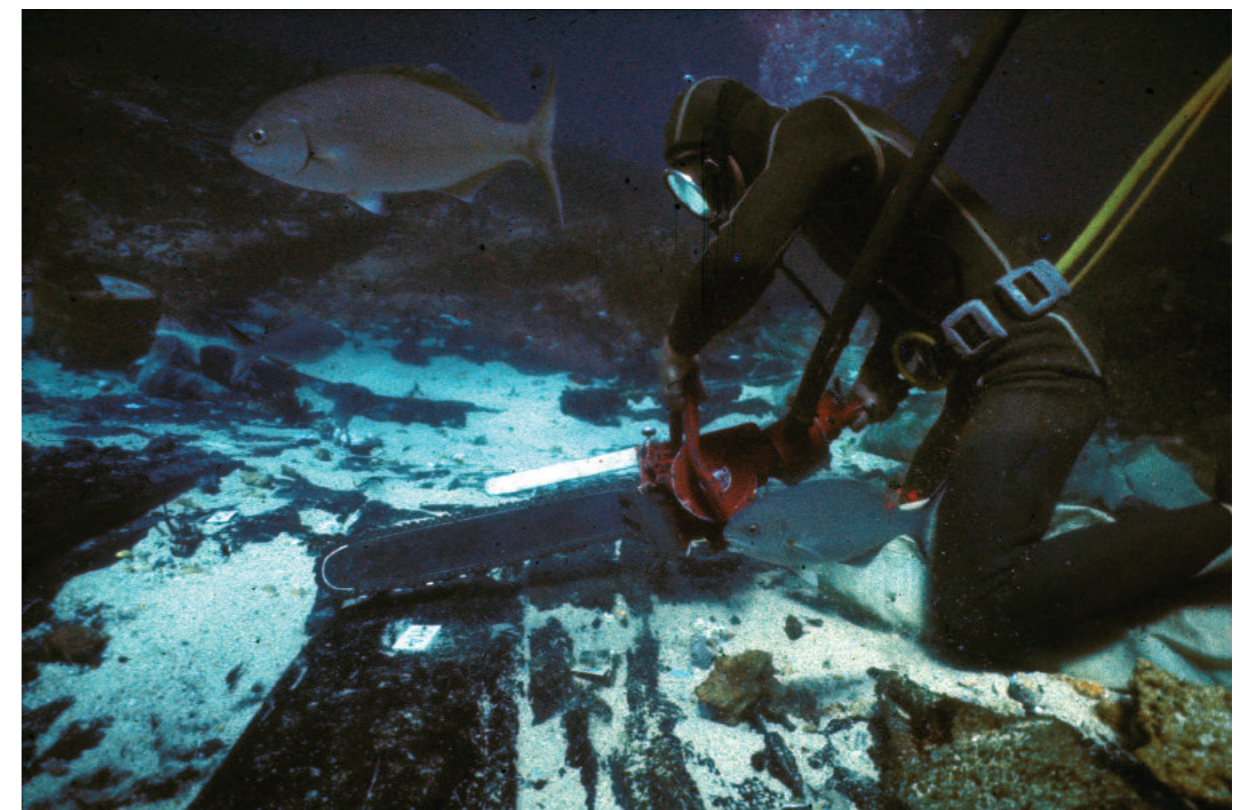
Hand fanning at the Tektas Burnu shipwreck, Turkey. © Jeremy Green

Where it becomes impractical to remove binding sediment using a combination of hand fanning and dredge or airlift, other tools can be used. These tools are generally used specifically for that particular task. Crumlin-Pederson reported that in the excavation of the Skuldelev ships (a cofferdam excavation), they brought a collection of kitchen scrapers and toy shovels to help excavate the ships, instead of the normal archaeological trowels. These were rapidly replaced by garden hoses with a trigger jet nozzle (Crumlin-Pederson and Olsen, 2002, pp. 34).

It is likely that every conceivable hand tool has been used at one time or another and in some circumstances tools have been created with a particular job in mind. Brushes, dental picks, trowels, hammers, chisels, shovels, crowbars, thermal lancers, pneumatic and hydraulic tools have all been used to free an object from its matrix. In exceptional circumstances explosives have also been used to help facilitate an excavation, but these were selected only after careful consideration of the impact on artefacts (Rule, 1982, pp. 128 and Green, 2004, pp. 268).



A gudgeon being hammered out of concretion, Norfolk Island. © Nigel Erskine



A chainsaw being used at the Batavia site. © Western Australian Museum



A pneumatic lift. © Western Australian Museum



A thermal lance. Xantho site. © Western Australian Museum

 **Suggested Reading**

- Crumlin-Pedersen, O. and Olsen, O. (eds.). 2002. *The Skuldelev Ships I. Topography, Archaeology, History, Conservation and Display*. Ships & Boats of the North, Volume 4.1, pp. 34.



A three pronged hand tool, Koh Kram, Thailand. © UWA

2.3.1 Airlifts

Airlifts can be constructed in various ways. A common feature is a long discharge pipe (usually made of PVC or aluminium) with a diver controlled on/off tap, which can also be used to regulate the airflow and strength of the suction. Regulation of airflow can alternatively be controlled on the surface, but this necessitates good communications between the diver and deck. Other design variations also exist. Martijn Manders (pers. comm., 2012) states that in the Netherlands they have, 'developed an airlift that can be regulated on the mouth piece, which is a flexible tube running horizontally over the seabed into the excavation pit. The tube itself is away from the pit. With a special system we can open and close the sides of the tube; hence suck less or more on the mouth piece.'



An airlift design.
© Christopher J. Underwood



Demonstration of operating an airlift.
© Mark Beattie-Edwards

In broad terms, airlift efficiency increases with water depth because the air expands as it ascends. Practical qualifications to this statement exist in that to obtain the increased efficiency, the discharge pipe must reach the surface and with greater depth there is a reduction in air pressure through friction in the air delivery hose. Airlifts are also less effective in water depths of less than 5 m.

The head size of an airlift pipe designed for archaeological purposes can range from approximately 10 to 15 cm in diameter. Airlifts of a larger diameter would require considerably more power to run, which increases the danger of rapid ascent should a blockage occur. As airlifts get bigger, they also can become increasingly difficult for individual divers to handle. Preference for particular bore sizes can be related to the task at hand. Where there is no danger to the site it may be preferential to use a bigger pipe diameter, particularly if you are removing overburden or backfill to a protective layer. A smaller bore airlift may be preferred when exposing small and fragile artefacts.

Divers should expose artefacts by carefully removing the sediments (ensuring that the context is recorded), using a hand, finger or hand fanning in light sediments, or another appropriate tool, such as a brush, for fragile organic materials. Small trowels can be used for more robust inorganic materials. Operation of the airlift requires it's near proximity to artefacts when excavating. The gently disturbed sedimentary material goes into the water column. The airlift suction then pulls the loose sediment into the pipe, removing it from the excavated area. The airlift is not in itself a digging instrument, but acts as a wheel barrow would on a terrestrial site and removes excavated material.

Controlled regulation of airflow, distance of pipe mouth from an excavated area and controlled hand fanning, mitigates the chance of any fragile organic or light objects being sucked up the pipe. Even experienced divers can occasionally lose artefacts up the pipe. On the HMS *Pandora* excavation, several very small intaglios were subsequently found in the spoil heap, consequently it is important that the spoil heap is monitored and checked. Some individuals recommend having a basket or sieve at the other end of the pipe.

The most common problem with airlifts is that large pieces of coral, bedrock or ballast can get drawn into the mouth of the pipe and become jammed as they ascend. If the airlift becomes even partially blocked it will become buoyant, sometimes dramatically. A cross of wire placed across the intake will prevent most blockages. This potential buoyancy hazard can be prevented by anchoring the airlift to the seabed, but this will partially reduce its mobility and care has to be taken to avoid placing the anchors on sensitive archaeological areas of the site.

The power of the suction is also dependent on the difference in depth-related pressure between the top and bottom of the tube, and the amount of air injected. Consequently the size of the compressor will depend on the number of airlifts being used at any one time, the depth of the site and the diameter of suction tube. As a rule of thumb, large compressors need larger platforms to work from. Similar to water dredges, discharged spoil can affect visibility unless the tidal flow is used to help carry fine sediment away from the site.

Airlifts can pose a threat in that the diver can inadvertently be carried rapidly upwards if an airlift becomes blocked by an artefact or the diver's equipment. An advantage of airlifts is that they carry spoil high up above the site and when utilizing the current, can carry debris even further away (Green, 2004, pp. 258). The downside to this, however, is that the spoil heap is dispersed more widely and, therefore, it becomes more difficult to inspect it for lost finds.

Outflow from an airlift. © Western Australian Museum



Suggested Reading

- [Bowens, A. \(ed\), 2009. *Underwater Archaeology: The NAS Guide to Principles and Practice*, Second Edition. Nautical Archaeology Society. Blackwell, pp. 144-145.](#)
- [Green, J. 2004. *Maritime Archaeology: A Technical Handbook*. Second Edition. Elsevier Academic Press.](#)

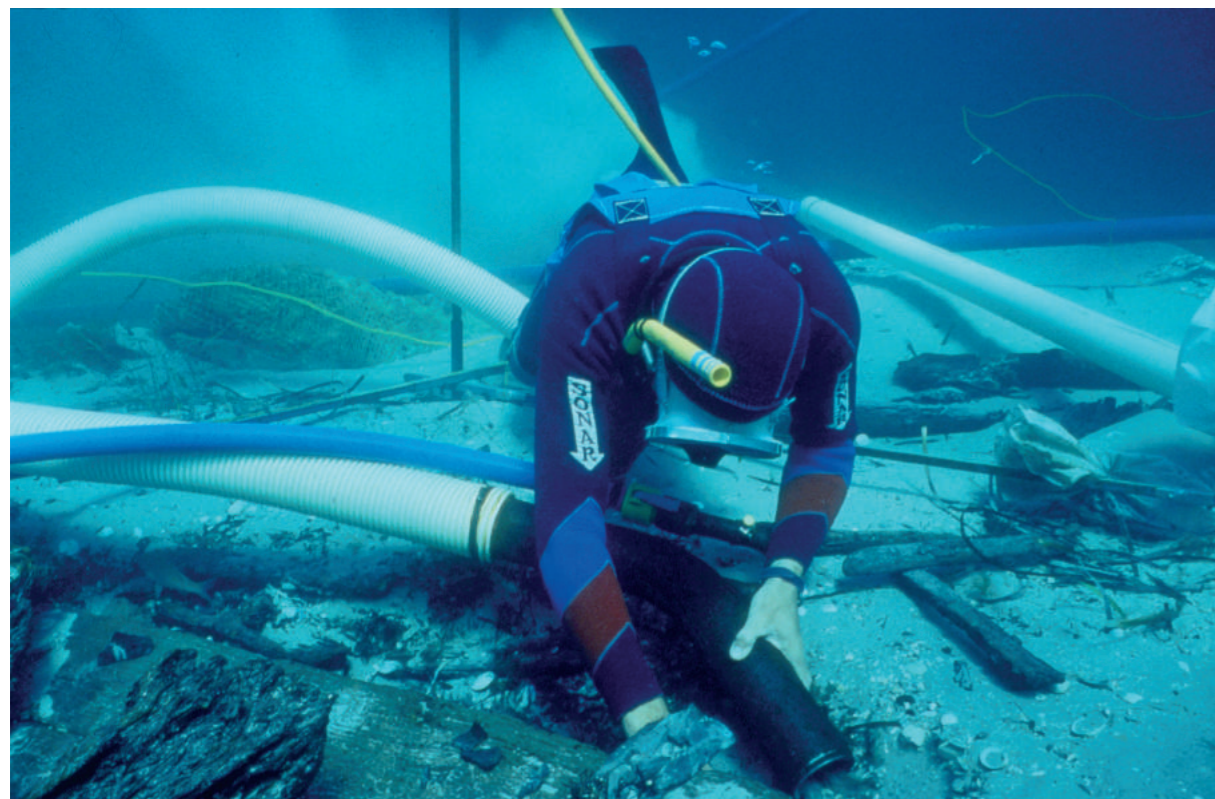
2.3.2 Water Dredges

Water dredges operate on the principles of the Venturi effect. The dredge is designed with a 90° elbow located near either the suction or discharge end, which enables pumped water to enter the dredge pipe through a restriction, creating a Venturi effect. The flow of water increases in velocity as it passes through the restriction, with a corresponding drop in pressure. The practical effect of this is dependant on the position and size of the restriction valve, and the working end of the dredge. Strong suction can be generated, resulting in an intake of water or other material into the dredge.



Water dredge equipment.
© Christopher J. Underwood

A diver using a water dredge to uncover hull timbers on the Sydney Cove shipwreck. © Parks and Wildlife Service Tasmania



Water dredges can be made from a range of materials, though commercial models tend to have stainless steel suction nozzles and a system for ease of handling, such as an arm loop and adjustable handle. The exhaust can be made with flexible hoses or PVC piping and can range in length up to about 15 m. Flexible hoses are easy to pack and transport, and are probably more common. The diameter of the dredges can also range from 7 cm to 15 cm. A hose from a low pressure, high volume water pump on the surface is attached to the Venturi elbow juncture. As with the airlift, material is sucked into the pipe and discharged at the end. This excavation technique is ideal in shallow waters, but is also employable at depths to approximately 50 m, although pressure losses due to hose friction can reduce performance.

One advantage of water dredges is that they are safer to use than airlifts, as there is no risk of rapidly increased buoyancy. Water dredges are also a good tool for shallow sites and have been used effectively at depths of around 30 m to 35 m. Water pumps are also generally smaller and lighter than an equivalent air compressor.

Water dredges, however, also have a number of disadvantages. One of the most prevalent of these is that dredges have no inherent buoyancy and operator fatigue can become an issue. Air filled containers attached to the solid pipe do make it more manageable and anchoring the dredge will prevent it from creeping forward from the force caused by the water discharging. As with airlifts, short hose/pipe lengths means that the discharged spoil from dredging can reduce visibility and tidal flow needs to help carry material away. Green (2004, pp. 258) notes that dredges do not work well when inclined upwards (although this can be resolved by running a flexible tube down into the hole), and that the ability of the dredge to discharge spoil beyond 5-10 m with a medium sized pump can cause problems when excavating a large site. This limitation based on the pump size requires careful planning to work around.

Suggested Reading

- Bowens, A. (ed.). 2009. *Underwater Archaeology: The NAS Guide to Principles and Practice*. Second Edition. Nautical Archaeology Society. Blackwell, pp. 145-147.
- Green, J. 2004. *Maritime Archaeology: A Technical Handbook*. Second Edition. Elsevier Academic Press, ISBN 0-12-298632-6.
- Underwood, C. 2011. *Excavation Planning and Logistics (HMS Swift 1770)*. *Oxford Handbook for Maritime Archaeology*. USA, Oxford University Press, pp. 150-155.

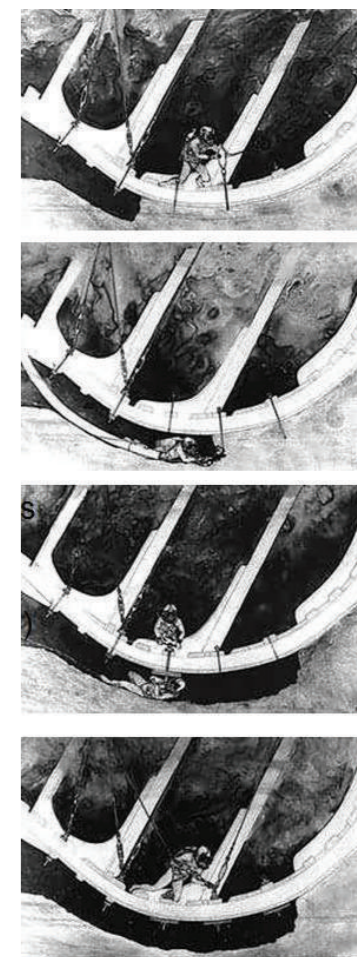
2.3.3 Water Jet

Water jet excavation involves a pump, a hose and a tapered nozzle. The constant volume of water being pushed through a small hole in the tapered nozzle causes the water particles to accelerate, which gives the water a cutting ability. Various industries utilize ultra-high pressure water jets to cut through materials, including metal. For example, in North Queensland, Australia, the technique is commonly used to cut all types of materials (including houses in half), so that they can be easily transported to another site. See: http://www.nlbcorp.com/water_jet_cutting.html (Accessed February 2012.)

For archaeological purposes, excavation involves the use of a relatively low-pressure pump (5.5 Hp), with a hose approximately 1.5 times the working depth and a tapered nozzle. The length of the hose is dependent on the strength of currents, which also adds significantly to the drag on the hose and increases the need for seabed anchoring. By adjusting the flow, either at the pump or by using the diver's on/off control, a gentle flow of the water can be controlled that induces a localized current over the excavation area, or alternatively, on full power, the water jet can be strong enough to cut through and remove hard-packed clays and sand (Underwood, pers. comm. 2011).

Its use as an excavating tool in an archaeological sense, is limited to situations where the water jet will not damage artefacts or the integrity of archaeological deposits, before they are mapped. A water jet was used extensively in preparation for the recovery of the hull of the *Mary Rose*, to cut away the sediment under the hull, a relatively benign archaeological area. These 'excavations' revealed the ends of the threaded 'pins' that had been inserted through the ship's hull timbers, to which were affixed the load bearing plates that enabled the successful recovery of the hull. If a full power water jet is used, the nozzle should have small holes for permitting a backward thrust of water. This eliminates the recoil and allows the operator to stabilize the hose.

Despite these advantages, Jeremy Green (2004, pp. 259) finds water jets of limited archaeological use underwater because of their propensity to create zero visibility. In these conditions its continued use would obviously have significant potential to damage the site. Green notes anecdotally that a water jet has an entertainment value, as a water jet (without reverse thrust to balance the backward force of the jet) can cause a diver to move in 'a random, uncontrolled and quite spectacular way around the site'.



This sequence illustrates the process of attaching the eye-bolts (inside the hull) to the backing plates (beneath the hull) of the *Mary Rose*. The backing plates were designed to conform to the hull profile which helped to spread the load on the hull during the lifting of the *Mary Rose*.

(1-Top) The diver is drilling through the hull structure using a pneumatic wood auger (2) The diver is excavating beneath the hull to locate the threaded bars pre-placed through the drilled holes (3) The diver beneath the hull is holding the backing plates in place while the diver inside the structure tightens the bolts (4) The diver is attaching the supporting cables to the underwater lifting frame that is positioned above the hull of the *Mary Rose*. © The *Mary Rose* Trust



Raising the Mary Rose in the cradle.
© The Mary Rose Trust

Suggested Reading

- [Bowens, A. \(ed.\). 2009. *Underwater Archaeology: The NAS Guide to Principles and Practice*, Second Edition. Nautical Archaeology Society. Blackwell, pp. 147.](#)
- [Crumlin-Pedersen, O. and Olsen, O. \(eds.\). The Skuldelev Ships I. Topography, Archaeology, History, Conservation and Display. *Ships & Boats of the North*, Vol. 4.1, pp. 34.](#)
- [Green, J. 2004. *Maritime Archaeology: A Technical Handbook*. Second Edition. Elsevier Academic Press, ISBN 0-12-298632-6.](#)
- [Underwood, C. 2011. Excavation Planning and Logistics \(HMS Swift 1770\). *Oxford Handbook for Maritime Archaeology*. USA, Oxford University Press, pp. 153-155.](#)

Unit Summary

Intrusive techniques are used in many aspects of underwater archaeology: to undertake survey and assessment of a site, in searching, sampling and of course, in traditional excavation.

The emphasis of the UNESCO 2001 Convention on *in situ* preservation does not preclude the use of intrusive techniques (see Unit 9: *In Situ Preservation*). *In situ* preservation is to be considered as a first option, however, excavation remains the archaeologist's most important tool to answer specific research questions and for understanding the sites that they are managing. It is only through careful excavation, which includes meticulous documentation and object management, that an artefact can retain its provenance and association with other objects and the site. The range of intrusive techniques outlined in this unit make up the toolbox of methods available to maritime archaeologists, so that their work can be done in the most effective manner.

Without a focus on retaining all contextual information with an object, the line between archaeology and treasure hunting is crossed. It is only through the post-excavation analysis of recovered material and its associated information, that an archaeologist can give insight into past cultures and life.

Excavation is a fundamental and necessary tool for archaeologists, requiring skill and knowledge. The use of intrusive techniques also requires an understanding of the implications of their decisions in the short, medium and long term. Consequently and critically, the rationale for excavation must always be done under the right circumstances and with the appropriate justification.

Suggested Timetable

15 mins	Introduction
75 mins	Introduction to Excavation - <i>When to use intrusive techniques on an archaeological site</i> - <i>Approaches to excavations</i> - <i>Techniques</i> - <i>Responsibilities</i>
	Break
90 mins	Intrusive Techniques - <i>Probing</i> - <i>Taking samples</i> - <i>Types of samples</i>
	Break
45 mins	Group Discussion
30 mins	Concluding Remarks and Closure

Teaching Suggestions

This unit provides students with an ethical, regulatory and archaeological framework to understand when to use intrusive techniques on an archaeological site and what techniques are available. It is recommended that the information is introduced to students in the form of a half-day introductory lecture. As excavation has long occurred in many parts of the world, most students will be familiar with a range of techniques and methodologies.

It is recommended that the introductory lectures are followed by active student discussions to help facilitate a deeper understanding of the presented material. Language and culture issues need to be considered by the trainer so that as many students as possible can participate in the discussion.

The group discussion should introduce the ethics in archaeology and the idea that something can be legal, but unethical. The concept of *in situ* preservation as a first option should be discussed in depth as it provides the maximum archaeological potential for information recovery now and in the future.

Group Discussion

A primary aim of this unit is to have students understand the responsibilities that archaeologists have associated with an excavation. Using either small group discussions or a class led approach (or a combination of both), pose the question, when is it necessary or appropriate to excavate?

Alternatively, trainers can examine the Rules of the Annex included in the UNESCO Convention for the Protection of the Underwater Cultural Heritage (Paris 2001) and discuss the implications of the Rules on the archaeologist. It is important to highlight their obligation to prepare project plans, employ as non-intrusive techniques as possible, seek approval from competent authorities, funding, conservation and site management, documentation, reporting, curation and dissemination.

Trainers can also utilize the Ethics Press Kit from the Advisory Council on Underwater Archaeology (ACUA). The press kit can be downloaded from: <http://www.acuaonline.org/assets/2011/03/02/e313d3ce2e2f-f7dc8f6c55b824ed4060.pdf> (Accessed February 2012.)

Trainers can discuss the differences between ethics and legality and their relationship to maritime archaeology and pose the question, can treasure hunting and maritime archaeology be reconciled?

Useful Websites

- UNESCO underwater cultural heritage portal: www.unesco.org/new/en/culture/themes/underwater-cultural-heritage (Accessed February 2012.)
- The Nautical Archaeology Society: www.nauticalarchaeologysociety.org (Accessed February 2012.)
- The Australasian Institute for Maritime Archaeology: aima.iinet.net.au (Accessed February 2012.)
- Institute of Nautical Archaeology, Texas A&M University: nautarch.tamu.edu/academic (Accessed February 2012.)
- Museum of Underwater Archaeology: www.uri.edu/mua/ (Accessed February 2012.)
- International Journal of Nautical Archaeology: www.wiley.com/bw/journal.asp?ref=1057-2414 (Accessed February 2012.)
See Additional Information 2.
- ICOMOS International Committee on the Underwater Cultural Heritage (ICUCH): www.icuch.org/artman/publish (Accessed February 2012.)
- Commercial company advocating the ability of water jets: www.nlbcorp.com/water_jet_cutting.html (Accessed February 2012.)

ADDITIONAL INFORMATION

2 *The International Journal of Nautical Archaeology* covers all aspects of nautical archaeological research. The journal's themes are seas, ships, cargos, and the sailors of the past; subjects that have excited interest throughout history. The journal keeps readers abreast of the latest explorations, discoveries and technical innovations in the field. Studies about ancient ships, harbours and cargoes, whether from excavations or documentary sources, will be of interest to the naval architect, historian and archaeologist. Information on the well-preserved artefacts discovered through techniques of underwater archaeology is especially valuable since these materials are seldom, if ever, found in excavations on land.



Suggested Reading: Full List

- Atkinson, J. and Nash, M. 1991. Report on the Excavation of the *Hadda*. *Australian Institute of Maritime Archaeology*. 11.2, pp. 17-24.
- Baker, P. 1986. *Understanding Archaeological Excavation*. London, ISBN 0-7134-3632-8.
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- Bowens, A. (ed.). 2009. *Underwater Archaeology: The NAS Guide to Principles and Practice*, Second Edition. Nautical Archaeology Society. Blackwell.
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- Crumlin-Pedersen, O. and Olsen, O. (eds.) The Skuldelev Ships I. Topography, Archaeology, History, Conservation and Display, *Ships & Boats of the North*, Vol. 4.1, pp. 34.
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