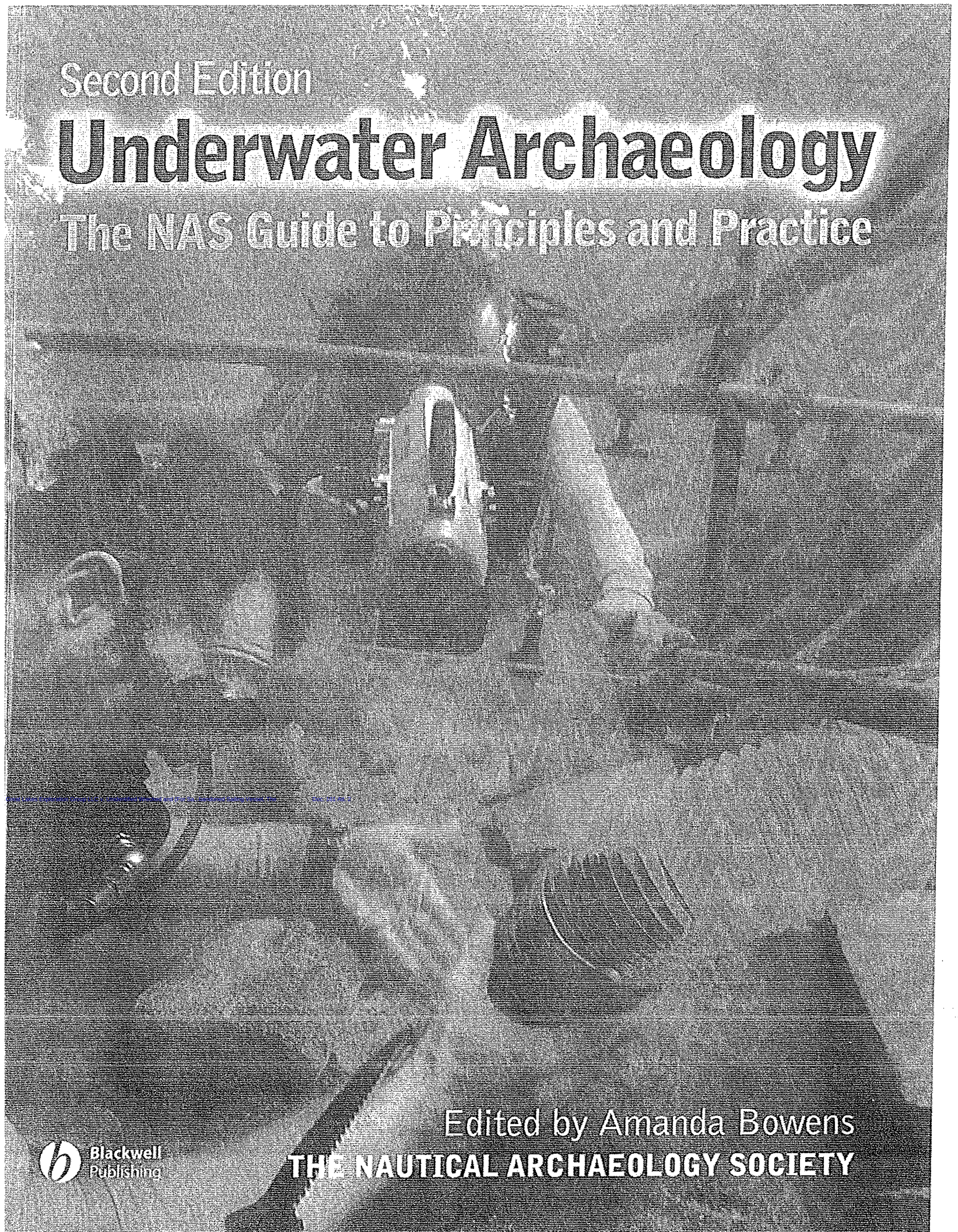
Second Edition

Underwater Archaeology

The NAS Guide to Principles and Practice



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THE NAUTICAL ARCHAEOLOGY SOCIETY

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to the National Grid or latitude/longitude. The methods of obtaining a position on the surface of the sea have been described earlier in the book (see chapter 11); this leaves the problem of accurately relating a point on the sea-surface to a point on the sea-bed. In shallow water, poles long enough to reach the surface can be placed on control points and their positions fixed using a 'total station' (figure 14.19) or DGPS ('differential global positioning system' – see chapter 11). In deeper water, a large buoy on the surface tied to a control point or heavy artefact can also work well. If the buoy is large, the rope can be tensioned, keeping the buoy above the point to be positioned; this method works best at slack water on a flat calm day. Any methods more elaborate than a simple surface buoy may be wasted effort, unless the surface positioning system is very good, because the amount the buoy moves from a position directly over the point is likely to be less than the accuracy of the surface position. To obtain a very accurate (300 mm/12 in absolute) position-fix in deep water, an acoustic positioning system can be used. This involves placing a transponder beacon on the point to be positioned. The APS positions the beacon by combining acoustic range measurements, depth measurements and positions from a DGPS receiver.

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Contents

Throughout this book, stress has been laid on the importance of survey and recording, not because excavation and intrusive techniques in general are less important but rather the opposite. Just as on land, underwater archaeological sites cannot be un-excavated, so the process is inherently destructive. That destruction can only be mitigated by careful planning, pre-disturbance survey, comprehensive recording, and publication. The decision to excavate under water is additionally onerous because the conservation of materials recovered from aquatic environments is often problematic and expensive (chapter 16). So although for the general public 'digging' has long been regarded as the quintessential activity of archaeology, these days a great deal of fieldwork takes place without it, not least because of the dramatic advances in the technology of remote sensing (chapter 13).

To take a purist stance, excavation could be regarded as a last resort in the investigation of a finite, non-renewable resource and this is reflected in policies of heritage management worldwide, which has been adopting the principle of preservation *in situ*. In essence, therefore, excavation is primarily justified in two ways: when research questions cannot be answered any other way and/or the site is under some sort of threat (Adams, 2002a:192). In practice, a third reason is training, although this is slightly different from the other two in that it should never be the sole justification for digging. That is the reason why 'excavation' is the only subject group in the NAS Part III syllabus that is not compulsory. Examples where training runs alongside research and rescue imperatives include NAS projects, university training digs or some of the excavations funded by government bodies such as English Heritage.

When excavation is justified, various strategies can be employed, and each must be evaluated in terms of the balance between information retrieval and impact on the surviving remains. The most destructive option, total excavation, might not be necessary. Many excavation strategies involve some form of sampling, using test pits, trenches or larger, more open areas (figure 15.1).

As well as ethical constraints there are also practical issues to consider before excavating under water. It is often (though not always) more costly than other investigative techniques but it always requires a wide skills-base in a team with well-organized logistical support. This chapter briefly outlines the three basic methods that will disturb a site in search of clues: probing, sampling and excavation.

PROBING

The principle of probing is fairly obvious. It is an attempt to locate sediments or structures beneath the surface layers, but in practice it is not always as simple as it might seem. Systematic probing of a site may assist the evaluation of its extent, state of preservation and depth of burial (figure 15.2). However, since its operation relies on feel, the results of probing can be very difficult to measure and interpret. It is best used to answer only very simple questions, such as the depth of sediment over a buried land surface, or perhaps the extent of a buried wreck structure. As with core-sampling, because of the potential danger to fragile archaeological material, it should only be used after careful consideration of the consequences.

Probing will only be of lasting value if it is carried out systematically to answer particular questions. The nature

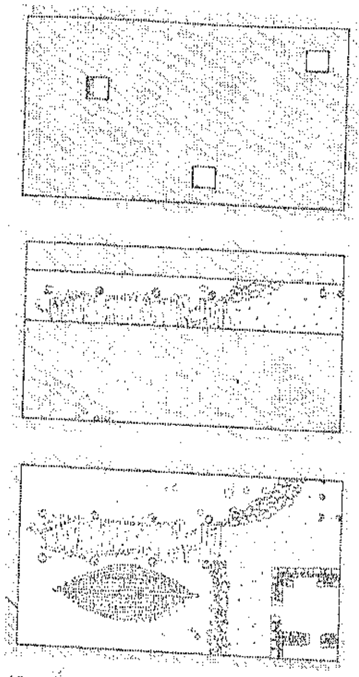


Figure 15.1 Excavation strategies: an example of the way different strategies – test pits (top); trench (centre) – will provide varying levels of information about the whole site (bottom). (Drawings by Graham Scott)

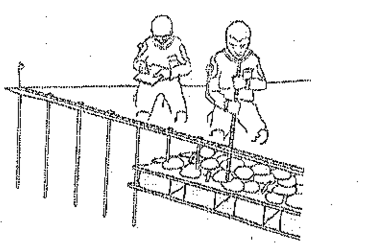


Figure 15.2 Probing to record sediment depths and obstructions can be an effective method of assessing the extent of some sites. (Based on original artwork by Ben Ferrari)

of the questions will dictate the probing strategy (e.g. readings taken at measured intervals along a line or at the intersections of a grid).

Types of probe: The simplest probe is a metal rod, thin enough to be pushed into sediment and thick enough to withstand bending. In practice, the resistance of the sediment imposes its own depth limit, beyond which it becomes increasingly difficult to distinguish a real obstruction. In these situations, or where the sediments are compacted, a more efficient probe can be made from tubing (e.g. 25 mm (1 in) bore steel pipe) down which water is pumped (figure 15.3). Only low water-pressure is needed to penetrate all but the most compact material and high pressure will cut through almost anything, including archaeological material. One of the drawbacks is that the water from the surface is often oxygen-enriched and this may upset the anaerobic environment in which fragile archaeological material survives.

SAMPLING

A sample is a representative amount of material that has been collected from an archaeological or natural context. Sampling for environmental or scientific analysis is relevant and appropriate for all sites. Samples may be taken for numerous reasons, ranging from dating to the identification of organic remains. There is a difference between collecting a sample of a material or deposit 'to see if there is anything in it' and taking a sample to answer a specific question.

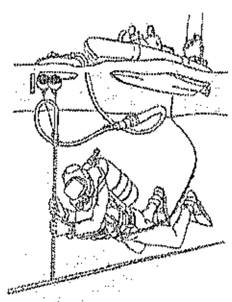


Figure 15.3 Air or water probes can be used to explore a site but are potentially destructive. In this example, measurements (distance along tape and depth of probe) are being relayed to the boat via diver-to-surface communications. (Based on original artwork by Ben Ferrari)

Samples should only be collected if three basic criteria can be satisfied:

1 There should be evidence that the sample will contain traces which will provide valuable information concerning the past. This is best checked by examination of a pilot sample either on site or in the laboratory.
2 There must be a sound reason for collecting the material. Specific questions should be asked, post-excavation analysis is made easier if objectives are clearly stated.
3 There should be a clear prospect that the material will actually be studied. This should be established by consultation with specialists before, or at an early stage of the archaeological investigation. However, important material should be sampled even if no scientific programme has been pre-arranged: a specialist can usually be found to work on material of significance.

These three criteria can best be satisfied if a clear strategy is agreed between the archaeologist and relevant specialists beforehand, or as soon as the problems become apparent during excavation. It is important to understand, however, that even after carrying out a detailed examination a scientist may be unable to provide a simple unqualified statement. Every method of examination has its own limitations. Often one analytical method must be employed to examine one group of phenomena and a second, quite distinct, method used to examine other aspects of the same sample.

It may be useful to attempt to divide non-artefactual or environmental archaeological remains into broad categories. For example:

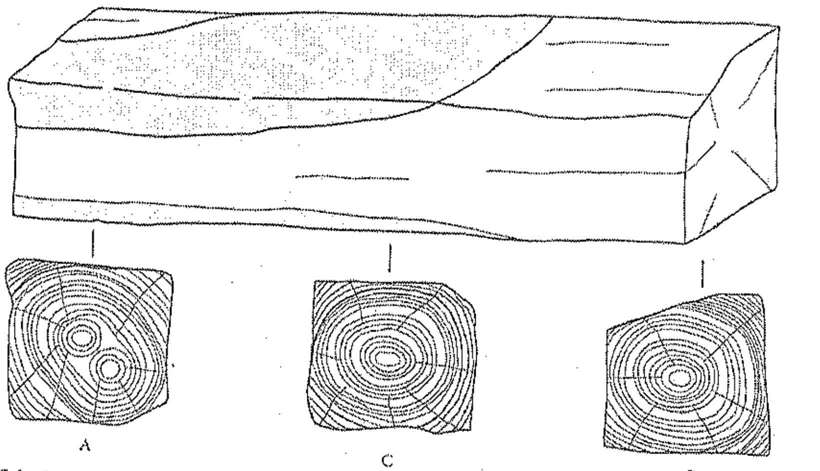
- *Economic* – Environmental archaeology can make considerable contributions to our understanding of the economy of a site or period. At its simplest level this may relate to what was eaten on the site. At a more complex level the environmental information can be used to reconstruct the contemporary agricultural economy or used to illustrate differences (such as social, religious or racial) across a site or between sites.
- *Environmental* – This refers to the sampling of deposits that may yield information on the general climatic, environmental or ecological conditions prevailing on or near a site. With respect to underwater sites, this may mean samples that can generate information about the formation of the site or, perhaps, data on the chemical and physical characteristics of the site and particular preservation conditions.
- *Behavioural* – The biological remains contained in certain contexts and/or their distribution across a site can relate to various aspects of human behaviour. At its most obvious, the threshing and winnowing of cereal crops on submerged settlements could produce recognizable patterns among botanical assemblages. The practising of crafts or commercial activities on board ship may also reveal itself in characteristic groups of animal bone or other materials on shipwreck sites. It may also be possible to interpret the function of specific areas or determine the original contents of containers.

An important part of any archaeological investigation is stratigraphy: the study of the various sediments, embedded structures and features that comprise the site's stratification (chapter 4). Apart from visual methods of characterization it may be necessary to take samples of the various layers present for laboratory analysis. Sedimentology – looking at particle size and composition through the depositional sequence – helps determine the changes that have taken place over time (see column sampling below).

The principles of radiocarbon and dendrochronological (tree-ring) dating have already been introduced as the two main techniques of absolute dating (chapter 4). There are many factors that critically affect how viable samples are for particular types of dating analysis.

Radiocarbon sampling: It is recommended that contact should be made with a radiocarbon laboratory at an early stage, if possible before any samples are taken. The following points should be taken into account:

- Never submit a radiocarbon sample unless the archaeological problem it is intended to solve is clearly identified. It may have nothing to do with chronology. Dates well-related to the span and significant events of site chronology should always be sought. Do not be wooed by potential samples simply because they are there. Always try to form an opinion on the chances that a sample will actually date the human activity or natural phenomenon for which a date is sought. In most cases there is no absolute certainty of association or contemporaneity.
- Before taking a radiocarbon sample from an archaeological deposit, section or core, study the nature of the deposit or layer and the stratigraphical conditions (such as geological complications, possibilities of humic contamination from higher levels, root penetration, visible animal activity from other periods).
- Collect more samples or a greater amount of sample than required for one dating because a later



A C B

Figure 15.4 Optimum place for tree-ring sampling: A) branching is distorting the ring pattern, B) no sapwood is present, C) there is undistorted ring growth and good sapwood survival. (Based on original artwork by Ben Ferrari; after Nayling, 1991:47)

check may be required or the sample may get lost. Estimate whether the amount of sample available is sufficient to provide the required precision in age. Realize that botanical, zoological or chemical identification is possible only before treatment in the radiocarbon laboratory.

- Pack the samples in plastic or aluminium foil or in glass bottles and write immediately the name of the site, sample number (depth and horizontal position) and the name of the collector on each packed sample. Send the sample to the laboratory as originally packed, together with full documentation.
- If samples have to be stored before submission to the laboratory, keep them in a cool, dark and dry place. Don't use organic preservatives and, in the case of shipwreck material, don't submit samples contaminated by waterproofing agents such as tar.

Sampling for dendrochronology: It is recommended that contact should be made with a dendrochronology laboratory at an early stage, if possible before any samples are taken (English Heritage, 2004b). The following points should be taken into account:

- The determination of a date for a structure will require a sample or samples of wood cut from well-preserved and long-grown timbers, preferably with sapwood surviving. Tree-ring sampling ideally involves selecting the widest part of the timber, free of branches and knots, and the sawing out of a 50–100 mm (2–4 in) thick slice. In general, ring sequences of less than 50 years will not date reliably. Size will not equate with ring-width as the growth rates of the original trees might vary considerably.
- Long ring-pattern sequences out to, and if possible including, sapwood are ideal for dating. Such complete samples will give the dendrochronologist the opportunity to sub-select the most suitable and informative samples for dating purposes, and also offer the option of characterizing the complete wood assemblage in terms of species, age and growth rate.
- A complete cross-section cut perpendicular to the grain is preferable, but a v-shaped piece from the back might be sufficient if the piece has been selected for conservation and display. In some cases, sections sawn from timbers can be tree-ring counted and then joined back to the main piece.
- Coring is also possible although it is recognized that it may cause compression and distortion of the ring sequence. An increment corer has been used successfully in dating boat-finds (for example, Tyers, 1989). A careful assessment should be made in choosing the optimum coring location with reference to the extent of the ring-sequence and the danger of damage to the outer (and perhaps most decayed) rings.
- Samples should be taken to provide the longest ring-sequence possible, including the latest surviving ring on the timber. For the greatest precision of dates, samples that include some sapwood, preferably complete, need to be identified on site and sampled preferentially (figure 15.4).
- Wood that is split or cracked may require support and strapping before sawing. Great care should be taken with the outer surfaces of the wood. This area may consist of sapwood that dries at a different rate from heartwood and it tends to become detached.
- Package the samples to prevent either physical damage or dehydration, and label them so that each is cross-referenced to the records of the original timber.

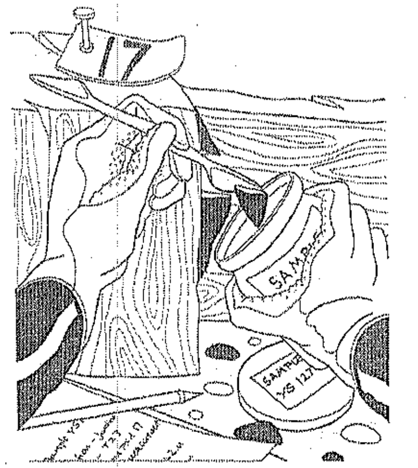


Figure 15.5 Taking a spot sample. (Based on original artwork by Ben Ferrari)

The decision regarding how much of the deposit or material to recover must be taken in the light of the answers to questions like:

- What is the deposit made up of? What is the principal component? Is it uncontaminated? The material that it is intended to sample for must have survived; the context must be well stratified and dated; and it must be possible to take a large enough sample to yield the required minimum of identifiable material in a manner unlikely to produce a sample bias.
- What is its potential? What can it reveal about the archaeology of the site?
- What will it entail, in terms of the excavation budget and resources, to recover all or a part of the deposit?
- What is the opinion of the specialist who will be providing the identification and interpretation?

Speculative sampling could be employed, provided that it formed part of a coordinated sampling programme (e.g. to provide test samples). Such samples should be processed and investigated with the minimum of delay and information about the quantity and range of evidence present can be quickly relayed to the archaeologist who has the opportunity to modify the excavation strategy relating to the original deposit. The planning stage of the excavation should include an assessment of the likely potential for scientific studies before and during the excavation itself and in post-excavation work. Account should be taken of the:

- time needed to carry out scientific work;
- cost (to include the cost of site visits and meetings as well as laboratory time);
- likely importance of the analysis, both absolutely and in relation to cultural archaeological studies; and
- intrinsic importance for the development of the discipline of archaeological science.

Spot sampling: These may be small local concentrations of biological materials (excluding wood). Examples are groups of fruit-stones, insect remains or small bones. Do not attempt to clean or separate the materials until they are transported safely to a specialist or more suitable processing conditions. General samples for biological analysis can be examined for the presence of many different kinds of remains (insects, fruits and seeds, parasite-eggs) depending on the nature of the material and the archaeological questions posed (figure 15.5).

The following is a basic procedure for the recovery of a sample illustrating some fundamental points:

- Have a suitable, clean container with a close-fitting lid ready.
- Identify the extent of the deposit from which the sample is to be taken.
- Record all locational details (such as relationships with other contexts, orientation of sample) on an underwater recording form/sheet in the form of measurements, sketches and notes.

- Make sure that the surface of the deposit is cleaned in the proposed sample area to reduce the risk of contamination.
- If a 'total sample' cannot be recovered, cut or gently separate a proportion of the whole deposit with a clean spatula or trowel. (Tools should be cleaned between samples to prevent cross-contamination.)
- Place the sample in the container and tightly fit the lid.
- If a number of samples are to be recovered on one dive, make sure that they do not get mixed up. Use pre-labelled containers or bags if necessary.
- Bear in mind at all times the possibilities of contamination. Note down any doubts.
- Record the quantity of the material or deposit that was actually recovered and how that compares with the original total deposit (even if it is just an estimate, such as '10 kg of an estimated 100 kg').
- Raise the closed container to the surface for prompt examination by the relevant specialist.
- Ensure that all notes are accurately transferred to the 'sample record form' (or equivalent documentation).

Coring and column (monolith) sampling: Chronologically stratified sequences, such as those found in naturally accumulated deposits (e.g. peats or lake sediments), should be collected in such a manner that will not disturb the sequence. Two possible methods are coring sediments down from the surface and the cutting out of a monolith of sediment (perhaps from a section face).

Column samples and monoliths are taken by inserting a channel or tube (of stainless steel or rigid plastic) into the sediment and then extracting it using the most convenient method to achieve an undisturbed sequence. Monoliths, or column samples, can be made up of a sequence of separate samples (figure 15.6). If the containers are pushed into the section, it is possible to remove large blocks of undisturbed sediment. Care should be taken to avoid contamination of the contents by smearing or the introduction of extraneous matter. All the containers should be carefully labelled with orientation, sample number, and location.

Further examination can take place under more suitable conditions, where contamination can be minimized. Sub-sampling of cores or monoliths for further analysis (e.g. for pollen) should be carried out by specialists or under their direct supervision. X-radiography of the undisturbed column may be useful for identifying layers or structures invisible to the naked eye.

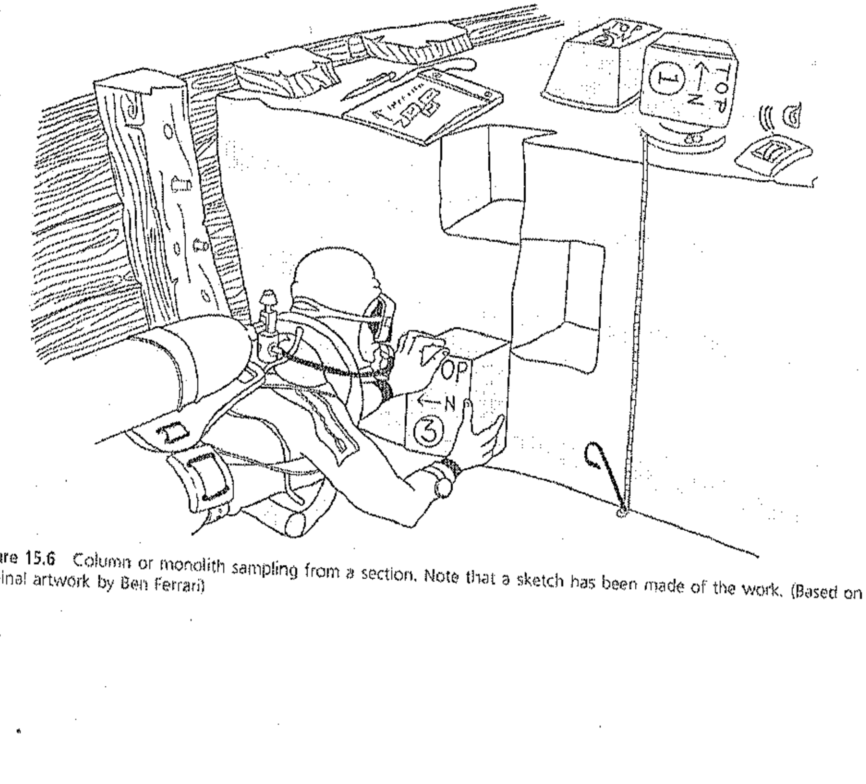


Figure 15.6 Column or monolith sampling from a section. Note that a sketch has been made of the work. (Based on original artwork by Ben Ferrari)

EXCAVATION

Archaeological excavation might be defined as the controlled dismantling of the contexts that form a site – sediments, surfaces, structures, objects and materials relating to past human existence – in order to understand their temporal, spatial and social relationships.

The aim of this section is to set out various methods and processes of excavation which have been shown to produce satisfactory results. This book cannot include every variation available, as each problem encountered prompts a slightly different improvisation. Nor can the use of any piece of equipment automatically lead to high standards of excavation. However, a sound understanding of the requirements of archaeological excavation, coupled with experience in the use of the equipment described below, will allow good work to be done in even the most unpromising circumstances.

A high standard of excavation is difficult to achieve without the necessary experience accumulated on a range of sites. Gaining excavation experience under water can be a long, drawn-out process because of the limited time that can be spent working under water at depth. It is further compounded by the relative difficulty of learning from others around you when under water. Another major constraint is opportunity. During the 1970s and 1980s in particular, several major excavations around the world involved large teams for several months, season after season. As there were far fewer professional diving archaeologists at that time, teams comprised professionals, students and amateur volunteers. Such projects are now few and far between, partly due to the factors discussed above and also because, in general, less underwater excavation is done these days in proportion to surveys. Even on the few developer-funded sites that involve underwater excavation, it is carried out by relatively small teams working within those contract archaeology companies which undertake maritime work (relatively few at the time of writing, though this varies between countries). It can therefore be hard to accumulate the skills required for a high standard of excavation. Yet training needs must be met and the onus rests with professional associations, organizations like the NAS and, hopefully, governments.

A concrete example, of course, are the NAS Part III courses (see appendix 3) which certainly provide a faster learning curve than is possible on most sites. The other valuable, some would say indispensable, way to gain meaningful excavation experience is to become involved in excavations on land sites. The principles and basic methodologies are exactly the same under water as on land; it is just that the environment differs.

It is important to define the area to be excavated and work to those planned limits. A disciplined approach is necessary for the following reasons:

- It increases the efficiency of the project by concentrating effort on the areas selected on the basis of their potential to answer the questions posed in the project design (chapter 5).
- Working in distinct, regular areas allows more efficient planning of subsequent investigations. The project will know where it has been because the precise limits of the excavation already undertaken will be recordable.
- Distinct boundaries of investigations help workers to be more thorough in retrieving all the elements of evidence necessary for interpreting the site. The inevitable damage caused by excavation is also then limited to distinct areas rather than spread over a larger area by wandering excavators.
- Disciplined work also has practical benefits, such as straight vertical edges at the limits of excavation to aid recording of stratification and the ability to concentrate site facilities such as airlifts and site-grids.

It should be impressed upon those carrying out the work that they must confine their attention to the defined area. This should be achieved in two ways:

1. A method of physically marking the work area will be necessary, such as rigid grids (which have the advantage of protecting the excavation edges) or line (which must be firmly anchored if it is to provide a permanent marker).
2. Effective briefing on the physical limits of the investigation, and the reasons for them, for those who will be carrying out the work will also be required. Without a reasoned explanation of the need for discipline, no amount of physical markers will produce a systematic excavation.

The diver's hand remains the most sensitive, accurate, and useful tool for fanning away or scooping silt towards the mouth of the airlift or dredge (figure 15.7). However, at intervals the working area may need cleaning or skimming with another tool to ensure stratigraphic features or other relationships remain visible. That tool is likely to be the 'mason's pointing' trowel, a fundamental tool on any archaeological excavation, whether on land or under water. The small 75–100 mm (3–4 in) bladed tool can be used either delicately or strongly, as circumstances dictate, scraping with the edge of the blade towards the body (figure 15.8) or, less frequently, using the point. In softer, less-compacted sediment, larger trowels can be used, especially for cleaning or scraping sections. Whatever size is used, they should have welded blades, as riveted blades tend to break at the attachment after prolonged use and exposure to seawater.

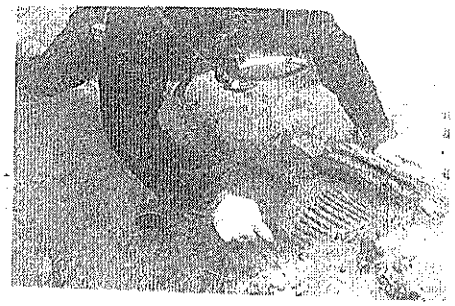


Figure 15.7 Excavating a wooden weaving heddle on the Armada wreck *La Trinidad Valencera* (1588). Note the delicacy with which the sediments are being removed – the archaeologist is using only an index finger to tickle away the spoil. The mouth of the water-dredge can also be seen – its only purpose is to carry away spoil, not to dig into the archaeological deposit. (Photo: Colin Martin)

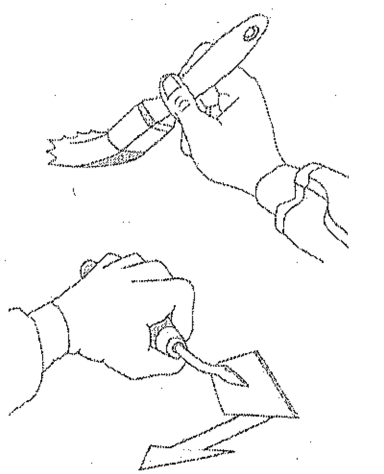


Figure 15.8 The trowel and the paint brush, along with the hand, are the most commonly used tools for excavation. (Based on original artwork by Ben Ferrari)

As indispensable as the trowel on underwater excavations is the paint brush. Larger ones are used like hand-brushes on land to clean surfaces. Under water they are particularly useful to clean timber surfaces prior to recording or photography. Smaller brushes (40–60 mm in width) are often the best tool in soft unconsolidated sands, silts and clays, especially when excavating organic and other fragile materials because it is almost impossible to do this with a trowel alone.

As well as trowels and brushes, many other hand tools and utensils are suitable for excavation such as teaspoons, dental probes, spatulas, knives and the like. Non-metallic tools are particularly useful where it is important not to damage delicate organic surfaces. Small tools are best kept in some form of submersible container to avoid accidental loss.

When excavating, the diver must be aware of the need for care in defining the contexts making up a site (see also chapter 4) and the nature of stratification. An excavator should aim to remove the layers in the reverse order of deposition. Deeper deposits should not be touched until overlying contexts have received adequate examination and recording.

Some sediments may not allow clear layers to be excavated sequentially. In this situation, control can be maintained by excavating in measured spits (e.g. removing an arbitrary layer 10 cm (4 in) deep). The exposed surface is then cleaned, recorded and the sequence repeated until a recognizably different layer is reached. Later analysis of these apparently homogeneous spits may allow useful evidence to be extracted. Lack of apparent layering is not a justification for uncontrolled excavation technique; neither is the use of spits an excuse for ignoring context differences. Depth of excavation, known as arbitrary excavation, alone is not a reliable method of relative dating (see Harris, 1989:119). Where layers are difficult to distinguish, it is more important than ever to keep the work orderly and neat. Allowing an excessive amount of loose sediment to build up may mask subtle changes and also small finds.

Contexts and stratification should be recorded, in the first instance, from above as they are noted or uncovered. During survey, this is all that will be available. However, the opportunity should also be taken during excavation to record them from the side as they are cut through. This can give added information about the relationships between the various contexts (see chapter 8). There are three ways of achieving this, all of which may be used during the same excavation:

1 Permanent sections will exist at the edge of the site where the sediments have been left unexcavated. These sections are termed permanent because they are unlikely to be removed as the excavation progresses.
2 Temporary sections can be used to record contexts not represented fully enough in the permanent sections. During excavation, part of the context or contexts is/are left unexcavated while a side view is recorded. The rest of the context can be removed and excavation continued. Since context differences tend to be more distinct when cut through, so temporary sections can be used as an aid to excavation. If a vertical face is maintained during the excavation of a context, any intrusion into underlying layers is more easily noted and stopped before it goes any further.
3 In mobile or deep sediments where these standing walls of sediment would be impossible or unsafe, cumulative sections can be recorded. This is simply the process of recording the section of each individual context before it is obscured by shoring, sandbags or a sloping excavation face. With accurate measurements along the same line, the section drawing will build up layer by layer throughout the excavation, resulting in a picture of the sediments cut through at that point.

Ideally the sides of the excavation should be as vertical as possible so that a true stratigraphic sequence can be recorded in one plane at 90 degrees from the horizontal. It helps considerably with stratigraphic analysis if plans and sections are relative to the natural horizontal datum. If for some reason it is not possible to compile a cumulative section, an alternative is to record information from a sloping or stepped 'section'. This is less satisfactory because relationships may be distorted by variations in the layers either side of the line of the section. Objects and structural remains should be left in place if they are sticking out of the section. Burrowing in after the object will only weaken the section and obscure the layers. However, when the section has been recorded it does provide an excellent source of samples of the various layers.

The positions of sections should be marked out. In the case of temporary and cumulative sections, which may not be immediately obvious, they should be clearly explained to other divers working in the area lest they unknowingly cause damage. Safety is, of course, paramount in these matters and unstable excavation faces can be a serious hazard. Sandbags and shuttering should be used where necessary.

Careless removal of objects will seriously compromise the results of the excavation so careful attention must be paid to the ways they are excavated and recorded prior to recovery. It is not acceptable archaeological practice to pull objects from the sediments that surround them for a number of reasons including:

- the risk of breaking the object;
- the risk of damaging other items close or attached to it which have yet to be exposed;
- failure to record the association of nearby objects; and
- failure to recognize which archaeological context it is associated with.

With objects that are reasonably robust, excavation involves systematically reducing the surrounding sediments until the object is sufficiently exposed for recording. The object is then lifted in an appropriate container or cradle, etc. However, as they become more exposed, objects are increasingly susceptible to damage, either from the activities of divers or from environmental factors such as current, water-borne abrasives (sand) and burrowing fauna. It may be necessary to physically protect and support exposed objects during excavation. Mechanical strength can be added by splints and padding, but delicate objects will always need a skilful excavator, and the co-operation of nearby divers, if they are to survive in one piece (figure 15.9). This is why, on sites where safety factors allow, excavators remove their fins, as these can cause extensive damage to both stratification and other archaeological material.

Figure 15.9 A conservator removing the surviving section of a gunpowder barrel, excavated from the Spanish Armada wreck *La Trinidad Valencera* (1588). The object had been secured with bandages before extraction and then placed in a container that was filled with sand and then lidded before being raised to the surface. (Photo: Colin Martin)

Even these measures may be inadequate for the most fragile objects such as textiles, leather and other very friable materials. These are best recovered with some of their surrounding sediments, usually by transferring them into a suitable container. This also avoids the object collapsing under its own weight, which would be the likely result should it be lifted from water into air. The whole procedure takes practice and if possible should be done by someone who is familiar with the type of object being recovered.

Some material will not need to be recovered after it has been exposed and recorded (e.g. ship's structure). Provision must be made to protect it in the long term. This may involve reburial, usually involving lining the trench with a protective membrane, held in place by sand-bags. The trench is then 'backfilled', either with some of the sediment removed during the excavation or, alternatively, with a sediment of specific characteristics brought in for the purpose.

Underwater excavation, just as on land, consists of two distinct procedures, each of which has its associated tools: 1) the actual digging and 2) the removal of 'spoil' (the unwanted sediments loosened in the process of digging). Although excavation can often be carried out by the same tools used on land, spoil-removal under water is very different. Occasionally the current alone is sufficient but normally some form of suction device is used, adapted from those first developed for industry. One of the mistakes of early excavators was to use these suction devices as the means of digging, in effect conflating the two activities. If control is the most important aspect of responsible excavation, then maintaining this distinction is vital.

The act of excavation is one of constant decision making – how deep to dig, what to cut through, where to cut to, etc. The by-product of this activity is loose sediment. Some of this may be recovered with an object or it may be recovered as a sample. The rest is 'spoil', having been judged not to contain sufficient information to keep. This judgement is not only the province of the individual excavator but of the trench supervisor and ultimately the site director. Once created, spoil needs to be removed. Just as spoil produced by the use of a trowel on land can be removed by shovel, bucket, wheelbarrow or conveyor belt, so various tools are used for the same purpose under water.

The airlift and the water- or induction-dredge are suction devices originally invented for other industries but which have become ubiquitous in underwater archaeology. In the past, they have been described as the underwater equivalent of a shovel, but their real function is to move unwanted excavated material (spoil) away from the excavation like a wheelbarrow or bucket. In this sense, they are one of the advantages of underwater excavation because once in operation they are virtually automatic.

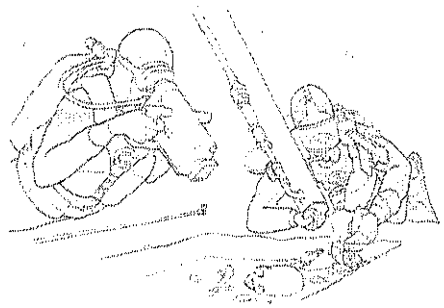


Figure 15.10 Excavation using airlift. (Drawing by Graham Scott)

Airlift

The airlift is a simple device consisting of a rigid tube into which air is injected at its lower end, usually from a compressor on the surface (figure 15.10). As the air rises towards the surface, it lifts the tube to near vertical and creates a suction effect at the bottom. Water and any loose materials are pulled in and up. The power of the suction is dependent on the difference in depth-related pressure between the top and bottom of the tube, and the amount of air injected.

Airlifts can be run from any source of compressed air but are best powered by the sort of road compressors used for pneumatic tools such as jackhammers and rock drills. These provide large volumes of air at low pressure (between 7 and 10 bars (100–150 p.s.i.)). Neither high- nor low-pressure diving compressors provide sufficient volume. The size of compressor required depends on the depth of the site and the size and numbers of airlifts that will be used simultaneously. The smallest air-tool compressors deliver 2 cubic metres (275 ft³) of air per minute and this is adequate to power two airlifts. In no circumstances should such a compressor (or any other air source) be used to supply air to divers and airlifts at the same time.

The limitation of these compressors is their weight; hence they need a sufficiently large boat or floating platform unless the compressor can be sited on land nearby. Another limiting factor is often the cost of such units although, for short periods, hire charges are not excessive, especially in relation to the total costs of excavation.

On small operations, the hose can lead direct from the compressor to the airlift. However, it may be necessary to secure the air hose to somewhere convenient on the sea-bed so that there is no additional pull on the airlift once the hose fills with air and becomes buoyant. On larger, long-term projects where more than one airlift is in operation, hoses led directly from the surface will inevitably become tangled and constitute a safety hazard. In this situation, it is better to have one delivery pipe from the compressor to a multiple take-off arrangement (manifold) fastened to the sea-bed. If this manifold is made from a long steel tube with a selection of take-off points (either manually or automatically valved), individual airlifts can be connected at convenient points by the divers. In many cases where the tidal flow will change direction by 180 degrees, it may be more convenient to have a manifold both up- and downstream of the site.

Prior to their first use on site, the airlifts need to be positioned and secured. The air hoses can then be connected or, alternatively, airlifts can be taken under water with the hoses already connected but this must be done prior to the air supply being turned on. If possible, they should be arranged on the sea-bed with the exhaust uppermost. Start up the compressor and allow it to reach working pressure. The excavator can now open the inlet valve. As long as the airlift is lying nozzle down, air will flow up the pipe and the airlift will slowly become vertical. If air merely bubbles out of the nozzle and the airlift remains stubbornly recumbent, simply lower the nozzle or physically lift the pipe slightly. Where it is difficult to do this, another method is to place a hand over the nozzle end so that the air cannot escape and so fills up the pipe. The danger with this technique is that the airlift becomes extremely buoyant. It should only be done if the nozzle is under a grid pipe and securely tied down. Once in operation, carefully adjust the air valve so the airlift is at a near neutrally buoyant state. If the airlift is too buoyant in operation, it needs to be ballasted with a little lead. Just as awkward is an airlift that cannot be made neutrally buoyant except on full power. In this case remove weight.

Careful positioning of the discharge is required so that the spoil does not cascade back down on top of the previously excavated or other sensitive areas. If the site has a constant tidal stream or current running across it, then the discharging spoil can be carried clear of the work area. If there is little or no current, the airlift can be restrained at an angle ensuring spoil drops outside the excavation area. If this is not far enough, the choice is between moving the spoil again (a measure to be avoided) or using a water-dredge. The problem with tying the airlift down is that it both restricts freedom of movement and reduces the ease of use.

If the discharge end of the tube projects out of the water, the weight at the lower end should be adjusted. Air in the tube when in operation gives more than enough buoyancy in most conditions and it should not be necessary to buoy the discharge end. Variations of design may be required for specific circumstances: 110 mm (4.5 in) corrugated plastic hose can be used at the lower mouth end to get into awkward areas of a site, but it is essential to have the air-flow lever within easy reach of the excavator so that s/he can shut off the air supply in an emergency.

The airlift must be used with great care. When excavating archaeological contexts, as opposed to removing backfill or weed accumulations, it must only be used as a means of removing spoil, normally swept gently towards its mouth using the hand, a brush or a trowel. It is best held in a comfortable position by the excavator some 20–30 cm (8–12 in) away from the surface being excavated, possibly further if there is anything extremely delicate being exposed. The valve on the air supply allows control of the strength of suction, and so allows very fine adjustment of the rate of silt removal. If it is not possible to control what is entering the tube during excavation, then either the excavation is progressing too quickly or the end of the airlift is too close to the working surface (plate 15.1).

A mesh on the suction end of an airlift or dredge should not be required to prevent objects being 'sucked up'; nor should there be any need for devices at the top to 'catch' objects that get sucked up. Sieves may be fitted periodically at the discharge end but only as a means of monitoring the standard of excavation.

Water-dredge

The water- or induction-dredge is similar to the airlift, except that it operates more or less horizontally, and it is water rather than air that is pumped in at the mouth (figure 15.11). It has the advantage of being cheaper to set up (because suitable water pumps are less expensive to buy or hire than compressors) and can work effectively in very shallow water. The water-dredge can have a flexible tube attached to the suction end to reach difficult places and increase mobility (plate 15.2) but, as with airlifts, the valve controlling the effectiveness of the device must be within easy reach for safety reasons.

The amount of water delivered to the dredge-head is probably the most important factor related to its efficiency. As a rule of thumb, a portable fire-pump with a 75 mm (3 in) outlet diameter will provide adequate power for two 110 mm (4.5 in) diameter dredges. Anything more than 1000 litres per minute is sufficient. Smaller water pumps with a 50 mm (2 in) outlet usually have insufficient delivery to provide anything more than a mild suction but, in many circumstances, this may be all that is needed. The smaller the water pump, the cheaper they are to buy or hire, and the less space they take up; the larger the pump the better the chance of having an effective dredge.

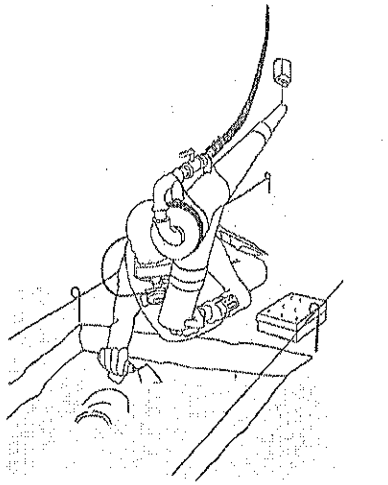


Figure 15.11 Water-dredge operation. (Based on original artwork by Ben Ferrari)

The water-dredge is used in exactly the same basic way as an airlift in that it should only be used to transport spoil fed to it by the excavator. It should not be used as a digging tool except when removing archaeologically unimportant material such as backfill from previously excavated areas, or collections of weed or other debris washed into the site during pauses in the investigation. Unlike the airlift it has no inherent buoyancy and so it is necessary to adjust it to what is most comfortable in any given situation. The dredge can be made neutrally buoyant by securely attaching one or two air-filled plastic containers (5 litre/1 gallon) to it (plate 15.3).

One of the disadvantages of dredging is the effect created by the water leaving the discharge end at speed, and the disturbance this discharge can cause on the sea-bed. This jetting can be dramatic, particularly if the pump is switched on when the diver is not ready. It is also potentially damaging to archaeological remains, and so must be neutralized. This can be achieved in a number of ways. Lengthening the discharge pipe so that its weight rests on the sea-bed can ease the problem but it increases the risk of discharge-end damage, and makes the dredge less moveable.

Discharge pipes can be positioned above the bottom by use of weights, or other forms of anchorage, and buoys. The pipe end can then be fixed at a suitable height. Anchoring the dredge-head end is also a way of reducing the effects of jetting, but it restricts manoeuvrability. If mobility is not a problem the discharge pipe can be extended well off site (distances of over a kilometre have been achieved) provided that more water is injected into the system along its length. A simple way of achieving this is to fit the discharge end of one dredge into the suction end of the next one in the chain.

One of the simplest ways of overcoming the jetting problem is to baffle the discharge stream. This can be achieved by attaching a flat plate or board across the discharge c.0.75 mm (3 in) from the end of the dredge. Alternative baffles can be devised. For instance, standard plastic soil-pipe fittings (such as a T-piece) can be attached on the discharge end, although these should be of a larger bore than the discharge pipe.

Alternatively, even a slow curve (not a tight 90 degree bend), positioned to discharge upwards, can be attached, in conjunction with appropriate buoyancy and/or anchorage. In such ways it is possible to achieve the desired effect on almost any site, and without damage to the archaeological evidence. The ingenious diver and archaeologist can no doubt think of many alternative solutions to these and similar problems.

It is possible to purchase ready-made induction-dredge heads built largely to supply the numerous operators who recover golf-balls from rivers and lakes in the USA. These are usually made of steel. However, it is possible to make a dredge-head from components readily available from hardware stores. As long as sufficient water is pumped down a tube and across the open end of a tube let into the side of the main tube, suction will develop at the other end of the side tube. The amount of suction will depend on the velocity and volume of pumped water and the overall effectiveness of the design. For instance, the water-inlet pipe should point exactly down the centre of the main tube, and there should be minimal obstructions to the flow in the large-diameter pipes.

Choosing between airlift and dredge

Generally speaking, the airlift is more efficient than a dredge, but requires greater resources to operate and is generally less effective in very shallow water. However, when choosing, it may be relevant to consider the different surface requirements for each type.

Both dredges and airlifts can be manufactured in a range of sizes: smaller for intricate work or, particularly in the case of airlifts, larger (e.g. 150–200 mm (6 in – 8 in) diameter) for tasks like the rapid removal of backfill or seaweed. To provide power for one 110 mm airlift, a somewhat bulkier and heavier compressor is required, although it may be possible to site it on shore and pipe the air out into the site, as has been done on several occasions.

Airlifts can be easier to handle than water-dredges, but where water depth is particularly shallow, a water-dredge may be the only option, particularly as it lies almost flat. However, the airlift can work well in a depth of less than 2 m (6.5 ft) provided a very large volume of air is pumped through it. Additionally, the airlift will also work with up to one-third of its length protruding above the water surface. Both tools can be controlled easily by the hand-operated valves, but can do untold damage if used in an uncontrolled fashion. As in all archaeological operations, it is in the best interests of the surviving evidence if the work is carried out in a careful and disciplined manner.

Water-jet

Another power-tool occasionally used is the water-jet. This is simply high-pressure water released through various shaped nozzles at a volume and pressure appropriate for the task. The indiscriminate nature of a high-volume and/or high-velocity jet of water, let alone its effect on visibility, limits its application on archaeological sites. Miniature versions, run off a water-dredge, however, can be highly effective for delicate work. Alternatively, a separate water-jet can be used in conjunction with a dredge. Small water-jets with a very low power are used in a similar way to brushes and are effective on organic material. As in all cases where delicate material is being excavated, however, do not experiment with a new technique or a new tool on the object itself.

Another use for water-jets is to induce an artificial current where it is otherwise very difficult to maintain visibility around the working area, such as in lakes. The technique was developed in Switzerland for excavation of prehistoric lakeside settlements. Water is pumped from the surface and directed through rows of small nozzles directed along and just above the bed.

Advantage should be taken of the unique ability of the diver to hover above the area under investigation. There are many techniques that can be tried. One advantage of a solid site-grid (chapter 14) is that it can offer additional diver support, and one technique successfully applied on a number of sites is to clasp the horizontal bar with the feet (one over, one under) to hang inclined at 45 degrees above the site (plate 15.1). Pressure applied alternately with either foot will allow the excavator to move around the area with complete control over his/her height above the archaeological deposits. When using an airlift, height can be adjusted by control of breathing or by slightly altering the buoyancy of the airlift as described above. However, the best means of control is to use the increase in the airlift's buoyancy that occurs when the intake is partially obstructed. The excavator simply holds the airlift by the rim and extends or retracts their fingers into the water flow making the airlift rise or fall respectively. This technique can be tricky to learn but once acquired allows excavators to lower or raise themselves into and out of sensitive areas with ease.

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