Environmental Archaeology, 3rd edition draft text

Summary
This document, its associated appendix and case studies, provides guidance for good practice in environmental archaeology. It gives advice on the applications and methods of environmental archaeology within archaeological projects, and how to plan these projects. It is a statement of best practice to all project stakeholders and intended to support the advice given by specialists.

These guidelines provide guidance to:

- those who advise local planning authorities (curators);
- those who write specifications or written schemes of investigation (advisors, curators, project managers);
- those working on both development-led or research projects, in both fieldwork and post-excavation contexts (practitioners);

What the guidelines cover:

- An introduction to environmental archaeology
- Good practice for environmental archaeology within project planning;
- Preservation and recovery of environmental evidence;
- Processing, reporting and storage of biological remains;

In addition, Appendix 1 supports an overview of a range of biological remains, their applications in archaeology, and their recovery as part of an archaeological project. It is further supported by the range of existing guidance produced by Historic England (https://historicengland.org.uk/advice/technical-advice/archaeological-science/)

1 Context of this guidance

1.1 These guidelines have been produced by Historic England in consultation with archaeologists, curators and environmental specialists. Since 1990 government spatial planning guidance in England, and in many other jurisdictions, has been based around the concept of providing reliable information to inform decision making (Darvill et al 2019). Though government planning policy changes over time, it is likely that the principles of informed decision making will be the basis of development and planning control for the immediate future.

1.2 Where projects are commissioned to inform the planning process in England the current National Planning Policy Framework (NPPF) makes it clear that the information sought should be proportionate to the significance of the heritage asset and the impacts of the proposed development on this significance. The NPPF also states that the purpose of studying the historic environment is not merely to record heritage assets, but also advance knowledge and understanding of them.

1.3 This guidance has been tailored for environmental archaeology as practiced in temperate climates, as found in England. Different climates will give rise to different preservation conditions and processes leading to different specialist considerations. However, the staged, iterative approach advocated here is applicable to archaeological projects wherever they are undertaken. This approach to project planning adheres to the principles of MoRPHE, which offers a framework for the planning and implementation of projects in the historic environment sector (Lee 2015).

1.4 Alterations to heritage assets of all sorts should consider the effect of change on elements of the archaeological record. For buried archaeological remains these alterations relate to any changes in the burial environment that may affect the preservation of the remains. In the case of construction activity this can affect remains directly (through physical disturbance), or indirectly (such as altering local water tables in the vicinity of waterlogged remains). These alterations can also include work undertaken within and outside the planning system, such as research by academic bodies, community groups, or interventions by individuals.

1.5 Best practice in all of these cases should consider the nature of the buried remains, the potential of these remains to add to the body of archaeological knowledge and to our understanding of the past, and how alterations to the burial environment will impact on their current and future significance, as well as their evidential value (Historic England 2016; English Heritage 2011).

1.6 When planning archaeological projects full use should be made of a range of sources of information on environmental archaeology potential (e.g. as outlined in 3.2.2). Environmental evidence is present in some form on all archaeological sites. Thus, the recovery and study of such material should form an integrated part of the initial project specification. It should not be added on as an unplanned for contingency or be un-costed.

1.7 These guidelines and associated appendix are intended to promote and advocate current best practice in environmental archaeology. Carefully considered new approaches are to be encouraged, however, novel methods should achieve a level of consistency with both accepted published methodologies, and with the general practice of the specialist community. This consistency is based on the experience of the wider profession, on-going research, and acknowledgement of new research questions. Departures from accepted best practice need to be justified, and their impact on the interpretation of results explained in advance of the project initiation.

1.8 This guidance highlights the importance of specialist input into all stages of archaeological projects, but also encourages all those engaging with the historic environment to consider their own experience and expertise when presenting or processing information. An aim of this guidance is to help archaeologists use their knowledge, and information from a range of sources, to better articulate the significance of the archaeological resource as a whole.

1.9 Early engagement between different project stakeholders has significant potential to improve the efficiency and effectiveness of the outcomes of archaeological projects. Good quality discussion as early as possible when planning a project enables better coordination of resources and improved outcomes. Getting specialist advice as early as possible is a key part of the pre-fieldwork preparation process. It is good practice for project managers to be in general contact with specialists for the most commonly encountered environmental remains from projects they are involved in. In England this would typically mean a specialist in zooarchaeology and macroscopic plant remains.

1.10 Additionally, advice can be sought from the Historic England Science Advisors. The Science Advisors are available to provide independent non-commercial advice on environmental archaeology and other aspects of archaeological science. They are based in the Historic England offices. Contact details can be found at www.historicengland.org.uk/scienceadvice.

2 **Environmental Archaeology: An Introduction**

2.1 Environmental archaeology is the study of the relationship between people and their environment through time. It is a fundamental part of archaeological study that uses the natural and physical sciences to investigate biological remains and the deposits in which they are found (Campbell 2018). It also encompasses such emerging disciplines as ecological history, biocultural heritage and the environmental humanities, as well as more traditional subject areas, such as palaeoecology and geomorphology. Everything we consume or have made ultimately comes from nature. Human societies do not operate outside of the natural world but rather both impact and are impacted by the world in which they live (Albarella 2018). Through its study we gain insights into ecological, climatic, and cultural change. The themes covered by environmental archaeology have been addressed in a number of general publications (Stevens and Wilkinson 2003; O'Connor and Evans 2005; Reitz and Shackley 2012, Richards and Britton 2020).

2.2 Archaeological sites and their surrounding areas can also include deposits or features that preserve evidence of the past environments, land use, landscape and climate change. Examples of such assets include buried peats, bogs, lakes, palaeochannels, alluvium deposits and colluvium deposits. The way human societies have been altering the natural landscape through time means many deposits which appear natural in origin are in fact the product of, and evidence for, human activity in the past including human niche construction and ecosystem engineering.

2.3 In the context of heritage management, an environmental archaeology approach can also provide a wider suite of information on buried archaeological remains, and their sensitivity to change. Understanding the range of material likely to be preserved in an area of archaeological interest is key to understanding the significance of the remains and their future management.

2.4 Like all archaeologists, environmental archaeologists seek to answer questions about people and how they lived in the past. Some typical questions include the following:

- What was the environment of the area like at the time of occupation?
- How did the environment change over time?
- How did people manage natural resources?
- How did people procure and prepare food?
- What did they throw away and where?
- What did people exchange and trade?
- Is it possible to identify social status?
- How were plants and animals used in rituals?
- How did people interact with, and impact, their environment?
- Was this site occupied seasonally or all year round?

2.5 There are also a range of questions that are of wider relevance to the planning of an archaeological project. This information can be incorporated into documents such as Desk-Based Assessments (DBA's), Written Schemes of Investigation (WSI's), and Updated Project Designs (UPD's).

2.6 Answering these questions is not solely the preserve of environmental archaeologists. Using experience, local knowledge, and an understanding of different types of archaeological remains, all archaeologists should consider how they already adopt an environmental archaeology approach into their day-to-day decision making. For example, this can be as simple as working on a site on free-draining, acid, sandy soils in a rural area, and anticipating that sediments may be particularly poorly suited to the preservation animal bone and molluscs, though may be good for the preservation of charred plant remains. Equally, when working in an urban environment, in an area where previously excavated sites have produced delicate biological remains and organic materials such as leather and bone, the assumption should be that these remains are also likely to be present in as yet unexcavated areas.

2.7 Examples of questions an environmental archaeological approach can help answer, which are directly relevant to development planning are:

- What sorts of burial environments are present across the development area?
  - How deep is the topsoil, subsoil, and bedrock? Are the surface/superficial deposits acidic or basic, and how will this help or hinder preservation of different types of material? Are there deposits present which represent evidence for the development of the topography such as alluvium, colluvium, or aeolian deposits? How does the local hydrology influence preservation?
- What sorts of materials are likely to be preserved within the development area?
  - If there are known heritage assets within the development area what sort of materials have been encountered on comparable sites, both regionally and nationally? In what ways are these materials vulnerable to change?
  - Are any materials vulnerable to activities which might alter the burial environment, and introduce oxygen, water, or temperature changes to buried deposits? What are the potential costs associated with excavation, conservation, post-excavation analysis and archiving? Based on experience and regional/national comparisons, what sorts of materials might be anticipated?
- Is there any external archaeological expertise which is required before the commencement of fieldwork?
  - Has the project manager considered whether external advice is needed? How typical is the site for the region, or for other projects they have worked on?
  - Have relevant specialists been contacted so all stakeholders understand what time constraints or costs need to be considered?
- Are there design considerations which could minimise the impact of the development on the archaeological remains?
  - Would discussions between the developer, their archaeological consultant, and the local authority archaeologist be beneficial as a means of understanding where design changes could be used to incorporate protection of burial archaeological remains, or enhance them as a heritage asset?

2.8 All those planning an archaeological project should consider these questions and decide what specialist advice they might require when developing an iterative programme for investigating the archaeological remains. On some projects it might be pertinent to utilise deposit modelling as a predictive tool for understanding the preservation potential of a site (Historic England 2020; see also Carey et al. 2018). If a plan is developed to preserve material in situ, then suitable engagement with an environmental archaeologist should be undertaken to create a preservation assessment and deposit characterisation (Historic England 2016).

2.9 It is also the responsibility of the environmental archaeologists to understand the needs of the project they are advising on. This includes the overall aims and objectives, the context of the project, and the research questions being proposed with reference to the regional research frameworks (The Research Frameworks Network - Research Frameworks). The production of specialist work should not be isolated from the project as a whole. Specialists must ensure that other project members understand why certain approaches are being advocated, and what the outputs of their work will be. Clarity of timescales, costs, and the suitability of proposed specialist work to answer project aims and objectives should be made clear at the outset.

3 **Environmental Archaeology in Project Planning**

3.1 Consideration of environmental archaeology is applicable to all archaeological projects. This includes desk-based research, the excavation and examination of buried archaeological remains, and the long-term management of buried archaeological deposits. These principles can also be incorporated into decision making by a range of project stakeholders, not only environmental specialists. In these guidelines the regulations, standards and guidance developed by the Chartered Institute for Archaeologists (CIfA) for archaeological work is treated as generally accepted best practice: CIfA Code, regulations and standards & guidance | Chartered Institute for Archaeologists

3.2 Desk-based assessment (DBA)
3.2.1 Consideration of environmental archaeology during the writing of a desk-based assessment is important to highlight the potential remains that may be present within the development/study area, and how these remains may be impacted by later fieldwork or ground disturbance activities. Much of the information of relevance to environmental archaeology planning is already collected as a standard part of the desk-based assessment process, therefore what is being advocated here is the consideration of this information within an environmental archaeology framework rather than the collection of additional information. Further details of this approach can be found in the Historic England Preservation of Archaeological Remains guidance (Historic England 2016, 5-19).

3.2.2 The following information in a desk-based assessment can be relevant to environmental archaeology, and all those writing such documents should check if this information is available:

- topography;
- solid geology;
- superficial deposits (also known as 'drift geology');
- soil type;
- aerial photographs;
- lidar survey;
- geophysical survey;
- borehole surveys and geotechnical test pits;
- hydrological and geochemical information;
- current land use and surface conditions;
- the nature of any previous ground disturbances;
- nearby archaeology remains/heritage assets;
- the nature and extent of the proposed ground disturbance activities.

3.2.3 Once information from the desk-based study is available, the potential for the survival and range of biological remains and deposits can be discussed with suitable experts. As a statement of good practice, those who organise and tender for archaeological work should be in general contact with an environmental archaeologist to help in planning and decision-making processes. Someone with experience specific to the region or site types being investigated is best placed to provide this advice. It is crucial to recognise that different sites or regions may produce different types of material and challenges for analysis. Experienced expert advice is essential at this stage to avoid a wasteful or misdirected outlay of resources, reduce project risks, as well as to avoid missed opportunities to advance understanding of the archaeological resource and other heritage assets. This includes the twofold challenge of a lack of understanding of the complexity of likely archaeological remains, or alternatively believing remains are unique and unexpected when they are common-place and well-studied in a particular region.

3.2.4 Questions addressed in a desk-based assessment should include:

1. What is the potential nature of preservation within the area being investigated?

2. Are there likely to be variations in preservation across the site?
3. What sort of material is typically preserved in the superficial deposits present in the area?
4. Are there local comparisons that allow inferences to be made regarding preservation of different materials?
5. What is the date and type of archaeological deposits likely to be encountered, and how might these affect the types of biological remains likely to be recovered?

3.3 Deposit modelling

3.3.1 It is good practice to consider a deposit model when planning a fieldwork project. Deposit models can be complex or simple in their construction depending on the number of inputs to the model. These inputs can include existing information, as well as specially collected and analysed material from specially commissioned investigations such as borehole studies. In determining what sort of deposit model is appropriate the archaeologist should focus on the outputs they need, and then determine what inputs are required to achieve these results. Deposit models can be complex, particularly in urban areas with deeply stratified archaeology that can be several metres deep. Deposit models of this nature may require specialist input from multiple individuals in planning for and constructing the model. Deposit models can also be comparatively simple, such as outlining various deposits in plan across a particular area.

3.3.2 On rural sites with shallow stratigraphy a deposit model is a useful way to visualise areas of differing archaeological potential, to consider the nature of preserved material, and where evaluation or excavation work can be most effectively focused. Whatever level of complexity is required a deposit model is also an effective means of communicating to project stakeholders the nature and type of remains present in the area being investigated, and how to plan for the collection of this material. Guidance on deposit modelling and archaeology is available from the following Historic England documents (Historic England 2015; Historic England 2020; Yendell et al 2022). Case studies relating to deposit modelling in a variety of contexts is also available as a free download from the following Historic England funded publication (Carey et al. 2018).

3.4 Watching briefs/Archaeological Monitoring

3.4.1 A watching brief is a form of archaeological fieldwork, and therefore consideration should be given to environmental archaeology. This includes observations of relevance to environmental archaeology and also provision to sample deposits for biological remains.

3.4.2 Good practice would allow for the possibility of sampling of archaeological deposits during a watching brief, and their publication (e.g. Jackson et al 2015, Case Study C). If sampling takes place it should be done to address a specific question raised by the watching brief. Even if no samples are taken during the project the resultant watching brief report should include a note on the preservation potential of the deposits/stratigraphy encountered.

3.4.3 The report should include:

- observations regarding the nature of deposits encountered,
- observations on the presence of organic and inorganic materials,
- evidence for the presence and extent of anoxic/waterlogged deposits,
- a statement of significance to inform future work in the area.

3.4.4 Observations made during a watching brief can significantly aid future, nearby fieldwork by highlighting preservation conditions. At a landscape or citywide level these observations can feed into larger projects such as urban deposit models, as at Berwick-on-Tweed (Derham 2013), Bristol

(Wilkinson et al 2013), Carlisle (Zant et al 2013), Boston (Cope-Faulkner et al 2017), and Droitwich (Hurst et al 2017).

3.5 Field evaluation

3.5.1 Evaluation seeks to understand the nature and extent of the archaeological resource This information will then inform decisions in relation to planning and future archaeological mitigation, including archaeological excavation. Recovery of environmental archaeological evidence is essential to inform this decision making. In some cases, a field evaluation might be the only intrusive archaeological intervention undertaken for a specific planning application. For this reason, the conclusions of any archaeological evaluation work must be robust, reported on and archived appropriately. In some cases, this may include full publication of results with associated costs.

3.5.2 Evaluation (typically involving the use of linear trenching, often testing geophysical results) will provide a much more reliable indication of the potential of the environmental archaeology resource than can be predicted from a desk-based assessment alone. Therefore, the desk-based predictions and assumptions should be refined in an iterative process. Sampling during an evaluation should inform the understanding of the potential and significance of the archaeological resource.

3.5.3 The sampling strategy, with its aims and objectives, should form part of the project design and consider:

- the nature of the range of biological remains present;
- possible variations in preservation;
- differential distribution across the site (vertically and horizontally);
- the significance of these remains in a local, regional and national context.

3.5.4 If required, provision should be made for specialists to make site visits to support sampling of deposits or recovery of other environmental material.

3.5.5 Assessment of biological remains from evaluations should be done to the same standards as for excavation. Assessments should clearly set out the significance of the studied material, the limitations of the evaluation process, and the potential of the evaluation work to alter previous assessments of significance.

3.6 Excavation

3.6.1 The strategies for recovering biological remains of all types should be designed to meet the aims and objectives as stated in the project design. The project design should be agreed by the project team, which includes the different specialists, and should build upon the results of any evaluation work. Within the planning/development management system, once a site has been proposed for excavation it has been deemed of suitable significance to warrant detailed examination. It should also be borne in mind that the site will either be ultimately destroyed by the development process or placed out of access for the foreseeable future in the event that the archaeological remains are preserved beneath the development. Therefore, decisions made at the project planning stage must ensure suitable attention is given to the range of archaeological evidence and ensure elements of their significance are fully recovered and investigated through effective fieldwork planning. In the case of archaeological deposits being preserved within the overall development, the input of the environmental archaeology team and archaeological conservators may be a determining factor in deciding if the proposed preservation plans are fit for purpose, given the likely wide the range of archaeological materials present (Historic England 2016).

3.6.2 It is the project manager's responsibility to ensure that all project members are kept informed during the progress of the excavation, including the discovery of important finds and factors that affect the environmental archaeology elements of the project. Significant changes or alterations in strategy should be agreed by the whole project team and recorded in the project documentation for future reference. Site visits by specialists should form part of the communications plan. Some specialists may need, or prefer, to take their own samples, or be present on site to advise on the recovery of certain materials. It may be useful on larger excavations to have a team member whose role it is to co-ordinate and monitor the sampling and recovery strategy, to identify when there is a need to call in other specialists, and to integrate different or non-standard sampling and recovery methodologies. This person needs to be experienced in excavation and recording methods and to understand the research potential of a wide range of biological remains. It is also desirable for this person to have a broad understanding of the range of scientific techniques applied to both the biological remains and other finds in the widest sense. It is crucial that samples which might require non-standard processing methods are distinguished at this stage – e.g. ensuring samples from waterlogged deposits or potentially waterlogged deposits are not mixed with samples that will be put through the standard flotation process.

3.6.3 Fieldwork should not be deemed complete until all the materials recovered are in a stable and archival state. The level of preservation of all recovered archaeological materials will never be better than at the moment of their excavation. Unprocessed sediment samples should not be kept without an agreed timescale for their processing and assessment by specialists. Keeping biological remains, including delicate organic artefacts such as leather, for long periods in an unprocessed state will only lead to further degradation and loss of significance. Though the timetabling and budgeting for this activity might come under the 'post-excavation' phase, best practice dictates that unprocessed material (material which has not been washed or processed to extract biological remains and finds), will remain as part of the excavation phase of work until all materials are in a stable and archival state. The only exception to this is where samples have been taken expressly for the purpose of future research. Where this is the case it should form part of the project design /WSI, with a clear outline of the storage or archiving of this material and its long-term maintenance.

3.6.4 Before the initiation of fieldwork, during fieldwork, and at its conclusion, it is useful to have meetings with both finds and environmental archaeology specialists to inform them of the site progress, and to keep the project management team updated on the post-excavation implications for the onsite sampling and recovery.

4. Sampling and Recovery

4.1 This section covers:

- what a good sampling and recovery strategy should include;
- asking the right questions;
- examples of possible methodologies;
- which types of samples to take;
- what to consider when taking samples;
- how to store samples;

4.2 In common archaeological parlance "sampling" is often used as a short-hand term for the recovery of sediment/soil from an archaeological layer/ context for specialist analysis. In this document sampling is taken to mean both the strategy for planning the recovery biological remains, as well as the physical recovery of these remains – be they recovered by the collection of archaeological sediments (sometimes referred to as ‘bulk samples’ in archaeological literature), or through collection by hand.

4.3 In environmental archaeology a sample is a fraction of the totality (population) of remains present in a context or feature. By further inference the totality of remains recovered is seen as representative in some form of past conditions or activity. The scale of environmental archaeology sampling (through the recovery of sediment, hand collection or sieving) is determined by the questions being asked, and the material being investigated. The intensity of sampling (the numbers of samples, their volumes, and the number/types of biological remains being targeted by this activity across the area of investigation) must also be proportionate to the overall project and its associated research questions/aims and objectives. The most important element in developing a sampling and recovery strategy is to understand how the information gained from the archaeological work (fieldwork and post-excavation analysis) will enhance knowledge of the period or site under investigation.

4.4 If the aims and objectives of the project are not clear it is impossible to work out the most effective way to recover environmental archaeology evidence, how best to deploy resources or how to modify the approach in response to newly arising issues or discoveries. Flexibility in response to new information or changing circumstances is an important part of project planning and management. This makes it possible to modify the aims and objectives as a project progresses and new information comes to light.

4.5 The need for sampling and a consideration of what types of samples and collection procedures will best address project aims should be considered at project initiation (see Case Study D). Advice should be sought from appropriate specialists to ensure that the sampling, and recovery strategies, will meet the project’s needs and use resources most effectively. The project design must demonstrate that the sampling and recovery strategies address the project aims and objectives.

4.6 A well-constructed sampling and recovery strategy addresses the aims and objectives of the project and how these fit into research questions identified in regional and national research frameworks. It is the aims and objectives that will determine;

- What remains may be present and how they can be recovered,
- Which archaeological deposits should be targeted to recover these remains,
- The sampling intensity that should be employed,
- The methods of recovery – flotation samples, hand collection, Kubiena or monolith tins, specialist sampling etc.

4.7 Logistical inconvenience should not be the driving force of how many samples to take, or determine the size of each sample, or what is collected. It is good practice to consider processing samples and other collected materials during the course of a fieldwork project. This can inform on the effectiveness of the sampling strategy and feedback into the ongoing collection strategy, as well as reducing the logistical burden of transporting and storing large numbers of unprocessed sediment.

4.8 Archaeological sites can be simple or complex in terms of their features, the deposits available for sampling, chronology, the properties of the deposits, and the site formation processes. These factors will influence the survival of different types of biological remains. Therefore, overall preservation will partly determine the extent and scope of the aims and objectives that can be set. While the survival of different types of environmental evidence can be predicted to a certain extent, it also relies on a number of assumptions which may change as the project develops. This is due to the complex interplay between numerous variables, with different categories of material having different taphonomic pathways 9see Case Study A).

4.9 It is essential to collect samples from all types of deposit that are relevant to the aims of the sampling strategy. Many classes of biological remains are not visible to the naked eye. In this respect appearances can also be deceptive. Dark deposits, for example, might be rich in organic silt but this does not mean they are rich in charred plant remains, while archaeological deposits that appear clean with no inclusions can be rich in charred plant remains, such as chaff, cereal grains and weed seeds (see Case Study 4).

4.10 Environmental archaeology remains may not be homogenously distributed through a given deposit, and this needs to be considered when taking samples. The most appropriate way of obtaining a representative sample of material within a context is to recover the sediment being sampled from different areas within the context (scatter sampling). A single sample of equivalent size from a single area in a context will be less representative of the context as a whole (Orton 2000, 153–4; Lennstrom and Hastorf 1992). This process also follows through to the processing stage where subsampling risks only identifying some of the material in the whole sample (e.g. if only processing 10 litres of a 40-litre sample). Subsampling the totality of the remains recovered on site should never be undertaken without a clearly articulated argument to justify this (see Case Studies 1 and 4).

4.11 If the objective is to explore variation within a context, multiple, separately identifiable sediment samples from different locations within the context will be required. For example: using a grid to sample an occupation layer. These separate samples can always be combined later, if appropriate. A single sediment sample cannot be meaningfully divided once taken to explore variation within a context.

4.12 A co-ordinated approach to the sampling and recovery of different environmental archaeology materials will provide a more enhanced interpretation than relying on a single line of evidence. Environmental sampling can also be integrated with sampling of various types of artefactual and technological evidence. For example, industrial working or production waste such as hammerscale can be recovered from the same sediment samples taken for charcoal remains for the purpose of studying fuel use.

4.13 Recovery of sediment samples should not only concentrate on features that can be dated or phased in the field. Recovery must also consider features that are undated at the time of excavation. Recovered biological remains can provide the material needed to date these features and, by ignoring them, some types of activity (or periods of activity), might be entirely overlooked.

4.14 Sediment sampling on excavations can be achieved using several different methodologies. The choice is primarily between random, judgement and systematic sampling. Common practice uses a combination of judgement and systematic sampling.

4.15 Samples should be taken from individual, discreet contexts, unless they are column samples that intentionally cross stratigraphic boundaries in a vertical sequence. Sometimes it is appropriate to sample thick contexts in spits, for example, of 50–100mm. Each sample must come from a cleaned surface, be collected with clean tools and be placed in clean containers.

4.16 A register of all samples should be kept, and should provide information on:

- sample type,
- reason for sampling,

- size of the sample in litres,
- context and sample numbers,
- spatial location,
- date of sampling,
- context description and interpretation.
- The approximate percentage of the context sampled should be recorded where known/ relevant.

4.17 Labelling must be legible, consistent and permanent. It is best to use plastic or plasticised labels and permanent markers. It is essential that all samples are adequately recorded and labelled. Samples without labels or in damaged or unsuitable containers results in information loss, and avoidable harm to the project archive and heritage asset. This can occur for a variety of reasons, but there is a greater risk if there is an unplanned delay between when the sample is taken and when it is processed of containers being damaged or labels becoming illegible or lost. Project planning should consider whether more durable plastic tubs should be used over less durable packing materials.

4.18 Samples in plastic tubs should be labelled both on the inside and on the outside. Samples in polythene bags should be double-bagged, and labels placed inside both bags and on the outside of the outer bags. Bags should be tied securely with synthetic string or cable ties. Specialist samples with an orientation, such as cores, columns and Kubiena tins need to have the top and bottom marked, the depth within the sequence of the deposit, and the height above and below Ordnance Datum recorded. Overlapping samples must have their physical relationship to each other noted. The position of samples should be marked on all relevant site plans and section drawings.

4.19 Specialists might also wish to make sketches and take separate notes. Photographic records of sampling taking place can be extremely useful in providing a complete record of sample position and orientation. It should be borne in mind that these records can form part of the final project archive. If it is decided that this is the case, they should be included in the data management plan for the project.

4.20 Samples from deeply buried deposits that are inaccessible to hand excavation are often taken using coring equipment (ranging from hand augers to larger drilling rigs), in order to recover sedimentary sequences that can be used for a variety of different analyses (Historic England 2015a; Historic England 2020)

4.21 Sampling in difficult conditions
4.21.1 Sampling of archaeological deposits can also be undertaken from non-terrestrial or atypical contexts; such as in the marine environment (see Case Studies 6 and B), in bodies of freshwater (including artificial bodies of water such as ponds and moats; Historic England 2018b), or from caves and fissures. All of these contexts present particular challenges and should be undertaken under the advice of an experienced practitioner.

4.22 Which types of samples to take
4.22.1 The archaeological context is important when deciding what types of samples should be collected. The likely presence of particular biological remains will be related to preservation conditions, to past human activities and to depositional processes.

4.22.2 The terminology applied to different sample types is varied. In part this reflects the wide range of materials for which samples are taken and the different processing methods used for them. These guidelines classify sample types primarily by how they are dealt with on site or who takes them. The use of the term ‘bulk sample’ is often used to refer to whole sediment which is recovered from an archaeological deposit and often sent offsite to be processed and analysed. However, it is important to recognise that this term applies to a range of sample types, which need to be processed and treated using specific methodologies. The term bulk sample is not used in these guidelines section as it fosters a lack of clarity about the purpose for which the samples were taken. Through the observation of the authors of this guidance, and supported by colleagues in the wider sector, there are also frequent scenarios where the inappropriate processing of a specialist sample leads to the needless destruction of the material being targeted. A common issue reported in the sector is using flotation as a means to recover plant remains or insects from waterlogged sediments, as opposed to following accepted best practice (Kenward et al 1980). Therefore, in this guidance samples have been classified into three basic types: flotation samples, coarse-sieved samples, and specialist recovery samples. Specialist recovery samples can be further divided into to three categories: general specialist samples, column samples, and core samples depending on the purpose for which the samples are taken and the method of sampling.

4.22.3 Both flotation and coarse sieved samples should be 'whole earth' with nothing removed, unless the way in which the sample is processed would have a detrimental effect on fragile material (e.g. intact animal mandibles with teeth that may be important for stable isotope analysis, or metal objects). Where items are removed, this should be noted on the sample record and on the material (find) removed and the information passed on to the relevant specialists.

4.23 Flotation samples

4.23.1 These samples are taken from well-drained deposits principally for the recovery of charred plant remains. However, they are often used to recover multiple strands of archaeological evidence including small mammal and fish bones, mineral-replaced plant remains, industrial residues such as slag and hammerscale (Collard et al 2006), and smaller finds. They are usually collected as part of the excavation process, and commonly seen on site being collected in plastic buckets. During excavation consideration should be given to where the samples will be processed and the logistics of their transportation. On large excavations there are considerable benefits to processing samples on site where facilities (water, adequate drainage and appropriate permissions to discharge, silt disposal and drying space) are available. This provides rapid feedback on the effectiveness of the sampling strategy employed and reduces transportation and storage costs.

4.23.2 Sample size will normally be of the order of 40–60 litres or 100% of smaller features. The washover/flot is usually collected on a sieve with a mesh size of 250–300µm (microns). Mesh size for flotation samples might need to vary from site to site according to the practicalities of processing different soil types. For example, where silty deposits are present a mesh size of 400-500µm might be considered to avoid the mesh becoming blocked. Residues are usually collected on a nylon mesh size of 0.5mm (500µm)–1mm and are sorted for the recovery of the small items mentioned above. The advice of a specialist with local experience or knowledge should be sought for the most appropriate sample size and mesh sizes for a given site. Specialist advice on mesh sizes will be needed particularly for sites on iron-rich clay soils, where charred plant remains are often partly coated or impregnated with iron salts, and where conditions are suitable for mineral-replacement by calcium phosphate or calcium carbonate (Carruthers and Smith 2020; Appendix 1, section 11). Only a small proportion of this material will float, with most remaining in the residue. In order to ensure full recovery of mineral-replaced remains the residue mesh should be 0.5mm.

4.23.3 It should be noted that flotation machines are not always highly effective at recovering charred plant remains, and that it is necessary to check residues to determine the quality of recovery. One method of doing this to re-float the dried and sorted residue. The dried and sorted residue can be placed into a bucket of water and the resultant floating material decanted through a 300-500µm geological sieve. Depending on the nature of the drift geology it has been observed that an increase of 10-90% of cereal grains can be achieved from refloating samples in this way.

4.23.4 For the recovery of finds (e.g. beads, flint, glass, pot), residue fractions larger than c 2mm can be sorted by non-specialists with the naked eye, although this should be done under appropriate supervision and with training provided. In practice most finds are recovered from the >4mm residue so it is worth considering what proportion of the <4mm residues are sorted and which materials are picked out as opposed to recorded (This process will be covered in more detail in forthcoming guidance - Commonly Occurring Finds in Sample Residues). Specialist advice should be sought as to the sorts of remains that might be present in the fraction finer than 2mm, and this work will need to be undertaken by someone with suitable training to identify this material.

4.22 Coarse-sieved samples

4.22.1 Coarse-sieved samples can be wet or dry sieved depending on the soil conditions and the materials being targeted for recovery. They are collected for the retrieval of small bones, bone fragments, larger molluscs (particularly marine molluscs such as oysters, mussels, limpets, etc) and smaller artefactual finds. They are best taken with the advice of the appropriate specialist. This process can recover other material incidentally such as wood charcoal, large plant remains (charred, waterlogged and mineral-replaced) and waterlogged wood, but coarse-sieved samples are not suitable as the sole means of retrieving these materials.

4.22.2 Coarse-sieved samples are usually sieved on a minimum mesh size of 2mm. However, full recovery of fish and small mammal bones requires a 1mm mesh or 0.5mm size depending on the remains being targeted (Baker and Worley 2019, figure 3.2; see also Case Study 2). The residues from flotation samples are also often used for this purpose (Barrett *et al* 2004).

4.22.3 Hand recovery of animal bones is always biased in favour of larger elements and will tend to over-represent the importance of larger animal bones, for example cattle over sheep, or long bones over foot bones. Specialist advice should be sought on sample size, mesh size and suitability of the context being targeted.

4.23 Specialist recovery samples

4.23.1 These samples are usually processed by individuals with specialist training, and in some cases the specialists themselves may prefer to take these samples when on site. The taking of sediment samples for flotation and recovery of charred archaeobotanical material is now a well-established process in England. However, it is felt that other sediment samples need to be distinguished from flotation samples as there has been an increasing trend, particularly for material from deposits with anoxic/waterlogged preservation, to be processed inappropriately using the standard flotation method.

4.23.2 They are referred to here as specialist recovery samples as the method of processing is often specific to the nature of the material being sampled, uses specialist equipment or chemicals. In addition, the material being recovered can be more sensitive to damage or bias if collected or stored improperly. This can include recovery of waterlogged plant remains, insect remains and molluscs, all of which require their own forms of processing and recovery. Some of these biological materials can be seen in flotation samples and can provide information on preservation conditions. However, for detailed analysis it has been shown that the recovered remains can be both statistically unusable and damaged beyond the point of useful identification (Davies 2008; Law and Davies 2018).

4.24.3 In some cases specialist samples will be subsampled to provide material for a number of different specialists. As per best practice, a specialist should have input as to the nature, volume, and context location of the material being sampled. Inappropriate sampling and recovery can materially affect the significance of the evidence being recovered, and thus affect the overall value of the report as a contribution to the fieldwork project. A frequent error is not recognising the presence of anoxic/waterlogged preservation because the sediment is not physically wet, or the archaeological trench does not contain standing water during the excavation.

4.23.4 General specialist samples
4.23.1 These can vary greatly in size, and the required volume should be checked with the relevant project specialist. The larger samples are typically in the order of 10-20 litres for waterlogged plant and mollusc remains, 2-5 litres for insect remains. For biological remains such as ostracods, diatoms, foraminifera, pollen, and parasites, samples can be in the order of 50 grams or less (See Appendix 1).

4.24 Column samples
4.24.1 These are collected from vertical sections. This can be in monolith tins/Kubiena boxes or in blocks of sediment cut from a cleaned vertical section. Samples taken on site can be subsampled in the laboratory for a range of analyses such as pollen, spores, diatoms and foraminifera as well as for micromorphology (see Historic England 2015a). Kubiena boxes are usually made of aluminium or stainless steel, with lids on the front and back. In order to collect deep sequences of deposits a series of overlapping monolith tins may be used. By whatever means they are taken, samples should be taken at a size suitable for the different types of material being recovered. Multiple sub-samples may be taken from each column depending on the range of biological remains being investigated. The vertical sections from which the samples are taken should be drawn, photographed and described. It is important to ensure there is coordination between the different specialists who might want access to these samples, as some processes may negatively impact on others; for example, excessive removal of sediment for one type of analysis may negatively impact on the possibility of utilising micromorphology.

4.25 Cores
4.26.1 Cores can be taken where it is not possible or desirable to collect columns and specialist samples from sections. For further details on coring refer to the Historic England Geoarchaeology Guidelines (2015a). The size, type of core and coring method used should be carefully considered at the project design stage (Historic England 2020).

4.25.2 Core samples may be recovered from locations with substantial accumulations of sediments, for example river channels, lakes, bogs, mires and glacial depressions, marine contexts (see Case Study 6 and B), or ditch sections and ponds. Sampling a long sedimentary sequence will provide information both regarding the site and regarding the wider ecological history of the area (Gearey et al 2016). Multiple samples of the same sequence from different but related locations will give a more accurate picture than a single sequence, which may be biased by local factors.

4.26 Human remains
4.26.1 The unique status of human remains as the remnants of once living people means that their treatment in archaeology involves legal and ethical considerations over and above those that apply to other classes of remains. The responsibilities of the human osteologist in an archaeological fieldwork project have been outlined in Historic England guidance (https://historicengland.org.uk/images-books/publications/role-of-human-osteologist-in-archaeological-fieldwork-project/heag263-human-osteologist-archaeological-fieldwork-project/). Further guidance documents covering various facets of the treatment of human remains is available from APABE (https://apabe.archaeologyuk.org/) and

BABAO (https://www.babao.org.uk/); perhaps the most pertinent of these in the present context is https://apabe.archaeologyuk.org/pdf/APABE_ToHREfCBG_FINAL_WEB.pdf, particularly the sections on human remains and the law, and the excavation of inhumation burials. Permission, under either secular or ecclesiastical law, is needed to disturb human burials. Excavated human remains should always be treated with respect and decency.

4.26.2 At the project planning stage, careful thought should be given to the type and number of burials likely to be encountered, as this will impact directly upon project costs.

Factors to consider are:

- Is the material likely to be from cremation-related deposits or inhumations or both;
  - Cremated remains (from prehistory to the late 7th century AD) will likely include other burnt material (mainly charcoal) which will require specialist analysis.
- Are grave goods or other grave furnishings likely to be associated with the burials;
  - Metal artefacts, such as copper or iron objects will have associated conservation costs and can also preserve MPOs (Mineral Preserved Organics) such a cloth and leather, which survive due to the toxic effects of metal corrosion products (Cronyn 2003). The analysis of MPOs requires specialists to work closely together and needs to be considered when resourcing a project.
- the likely level of skeletal survival in inhumation burials
  - Waterlogging may result in extensive preservation of organic remains of mortuary material culture occasionally including ephemeral items e.g. floral tributes in 19th century burials
- There may be specific health and safety considerations, for example where there is extensive soft tissue preservation, where lead coffins are present, or when working in enclosed burial spaces, such as crypts or vaults.

4.26.4 On excavation, each inhumation burial should be given a unique context number and dug by hand. If soil samples are to be taken to investigate the survival of gut parasites or food residues then these are normally taken, prior to the lifting of the bones, from the abdominal / pelvic area, together with control samples from the grave fill away from the body or inside the skull. After lifting the bones, the soil remaining in the base of the grave should be recovered and sieved to retrieve small bones, bone fragments, loose teeth, and any small artefacts that might be present. Exact procedures differ in detail according to the nature of the site, but it is often useful to recover the soil as three separate sub-samples relating to the head, torso and leg/foot regions, to show approximately where, in relation to the body, any recovered items came from. After sample processing, recovered skeletal material should be boxed with the skeleton in separate, labelled bags.

4.26.5 All cremation deposits should be 100% sampled. Generally, cremation deposits should be half sectioned and excavated in spits, with each spit retained as a separate sample. Vessels from urned burials should be block-lifted before being excavated and sampled. Larger crematory deposits, such as pyre sites, should be excavated as multiple discrete samples. Any fragments of charcoal greater than 100mm should be recovered as individual samples and 3D recorded. Flotation can be used to recover charcoal and other plant remains associated with the cremation rite. Careful processing is required to minimise fragmentation of any cremated bone. Samples can be gently dry sieved over an 8mm or 4mm mesh to recover the large bone fragments and finds prior to flotation. For further guidance on the sampling of cremation burials and related deposits see McKinley and Roberts (1993).

4.26.6 Best practice for the assessment, analysis, and scientific sampling of human remains is outlined in the documents highlighted above. The approaches to processing, reporting, and storage of environmental samples and biological remains outlined in the next section are not applicable in all cases to human remains. Therefore, the primary guide to the treatment of human remains should be published best practice and the recommendations of an experienced human osteologist.

5 Processing, reporting and storage of environmental material

5.1 Processing samples

5.1.1 A prime purpose of the archaeological fieldwork is to create a secure and accessible archive which can then be analysed during the post-excavation stage, and whose contents form the basis of the updated project design. In order to create a secure archive both flotation samples and coarse sieved samples, as well as and hand-collected material must be fully processed, to both stabilise the materials recovered and prepare them for deposition.

5.1.2 The effects of the delay between sampling and processing will vary widely depending on the material, its original burial environment, and the duration of the delay. Well-preserved mammal bone may be relatively robust, but deposits containing fish bones can be vulnerable to fluctuations in moisture and temperature. Likewise, waterlogged deposits containing delicate plant remains, insect remains, or animal fibres can rapidly degrade if stored in conditions with fluctuations in temperature, light, and moisture. In the case of charred plant remains the nature of the material means it is resistant to biological and chemical changes, however, when removed from its burial medium it is vulnerable to the physical damage that can result from wetting and drying episodes.

5.1.3 All sample processing should be recorded on sample records whose format is agreed by the project manager, the specialists and the on-site environmental supervisor. Processing records should include sample volume (for coarse-sieved samples and flotation samples), context and sample number, mesh sizes used, the date processed and any other comments or observations that will inform assessment and analysis.

5.2 Storing samples

5.2.1 Key points for storage are:

1 Keep samples cool;
2 Exclude light and air;
3 All relevant records need to be safe and accessible;
4 Avoid long-term storage without a processing or archiving plan.

5.2.2 Samples for laboratory processing should be collected by, or sent to, specialists as soon as possible. Once excavated, organic remains become more vulnerable to decay by micro-organisms such as bacteria, algae and fungi. It is not possible to prevent this process completely, but the rate of deterioration can be minimised. The general rule is to maintain samples in conditions as close as possible to those in the ground in which they were found, they should be protected from fluctuations in temperature, kept out of direct sunlight, and, as far as possible, stored in airtight containers. This will slow bacterial and algal growth. Organic rich samples should be monitored for fungal growth, which can also occur in dark conditions. Waterlogged samples should be well sealed to prevent drying out. If a waterlogged sample does accidentally dry out it should not be re-wetted but left dry and a note put in the sample record stating that the sample had accidentally dried out in storage.

5.2.3 As well as damaging the preserved biological remains, inappropriate storage can also impact on suitability for radiocarbon dating, through growth of fungal hyphae, or through plant germination and photosynthesis in a sample which leads to the redistribution of carbon (Bayliss and Marshall 2022, 47). With long-term and inappropriate storage these biological processes can also cause substantial damage to preserved biological materials. Therefore, samples should be processed as soon as possible to stabilise the archive.

5.2.4 Guidance on the curation of waterlogged plant macrofossils and invertebrate remains is given in Robinson (2008). Waterlogged wood should only be stored for short periods of time before it is recorded or sent for conservation, as the longer it is kept in storage the worse its condition will become (Brunning and Watson 2010).

5.3 Assessing significance in reports for environmental remains

5.3.1 An understanding of heritage significance must bear in mind the value and importance of the heritage asset, both to the current and future research community (Historic England 2015b; Historic England 2019). A contemporary consideration of current significance must include:

- examination of material to a high professional standard,
- ensuring archaeological material is not needlessly or carelessly destroyed,
- ensuring there is repeatability of results by protecting non-excavated remains where this is possible,
- ensuring excavated material is studied and archived in a manner that allows future researchers to interrogate the resulting material archive and datasets in line with FAIR (Findable, Accessible, Interoperable, Reusable) data principles.

5.3.2 The purpose of an assessment is to:

- establish the significance of the material,
- assess its potential to address project aims and objectives,
- assess its potential to enhance understanding of the past.

5.3.3 An assessment should take account of the results of previous interventions and make recommendations for the type and scope of further analysis. These recommendations should feed into the updated project design. To be cost-effective (both time and costings) these decisions should be made in the light of the best current knowledge and understanding, and therefore need to be carried out by specialist staff who are experienced in studying the type of material being assessed. For example, specialists need to be able to recognise the significance of interesting or unusual taxa, which may not always be found in the richest samples.

5.3.4 Assessment methodologies will vary according to the type of remains being studied and the research questions posed within the WSI /project design. The distribution and occurrence of biological remains and artefacts cannot be determined without examining what is present in the samples. As these samples will have been collected according to a strategy designed to meet project aims, this will normally mean that all material recovered should be assessed, unless there is a compelling reason why this should not take place (see Case Study 1). The justification for not assessing material must the recorded in the site report and project archive. The exception is where multiple samples have been taken from the sample context (e.g. across a floor area), or where a column of samples has been taken through a sequence of deposits. In these cases, it can be appropriate to only assess a subset of the samples taken. However, this sample selection process and the reasons for it should be articulated within the assessment report.

5.3.5 Information the specialist requires to carry out an assessment:

- brief account of the nature and history of the site;
- aims and objectives of the project;

- summary of archaeological results;
- context types and stratigraphic relationships;
- list of samples;
- phasing and dating information;
- sample locations;
- preservation conditions;
- evidence of residuality / contamination;
- other relevant contextual information;
- some indication of quantity (number of boxes, flots, etc);
- contact details of other project team members.

5.3.6 The assessment report should include:

- specialist aims and objectives relevant to the project;
- summary description of soil, sediments and stratigraphy, where relevant;
- sampling and processing methods, (including mesh sizes for sieved materials);
- assessment methodology;
- any known biases in recovery;
- any known problems of contamination or residuality;
- quantity/volume of material (e.g. how many samples? what was the sample size? How many standard archive boxes for zooarchaeological material);
- statement on abundance, diversity, and form of preservation;
- assessment of the state of preservation of the material (condition assessment);
- statement of potential to contribute to the project aims;
- statement of potential to contribute to research topics of wider significance;
- comparisons with analogous regional sites of the same type or period
- recommendations of material suitable for scientific dating, when this has been requested;
- recommendations for future work (analysis and publication);
- resources required for further work;
- recommendations for sampling strategies in case of further excavation;
- recommendations for retention and discard.

5.4 Analysis and reporting of environmental remains

5.4.1 The type and level of analysis required should be clear from the assessment report and updated project design, as agreed by the project team. The report should state aims in relation to the project design, methods, results and conclusions. Reports need to include clear statements of methodology, with the results of scientific analysis clearly distinguished from their interpretation. Non-technical summaries of results should be included, and the full data from the analysis presented. Access to data from other elements of the project will allow the production of an integrated report.

5.4.2 Analysis reports should include the following sections:

- Introduction
- Aims and objectives
- Methods
- Results – including the full data set (this can be included as supplementary data made available online and ideally in recognised data depositories)
- Discussion
- Conclusion

5.4.3 Overviews and syntheses of the environmental results will generally be written by one of the environmental specialists involved in the project in collaboration with other members of the project team. To avoid misinterpretation or technical inaccuracy, any integrated discussion incorporating specialists' results should be seen by the specialists who undertook the work. Contributions of this nature should be considered when estimating project costs.

5.5 Publication and archiving

5.5.1 It is essential that a report on any archaeological intervention should be lodged with the local HER as promptly as possible. This is necessary to inform future interventions and guide the local planning authority on future decision making. Environmental archaeology information should form part of this report, including any information on deposits and the preservation of biological remains.

5.5.2 The presentation of the full datasets in association with their interpretation should be encouraged in the main body of reports. At the minimum, publication needs to include the aims and objectives of the study, a basic description of the material, methods of analysis, interpretation of results and sufficient data to support the conclusions drawn. Information of interest to specialists within the particular field of study, including illustrations of unusual or important material should also be published, or where this is not practical full details of the location of the project archive and the environmental remains (including museum accession number and DOI) be included in the publication. The location of the archive should also be included, as should the scope and limitations of the study, as well as relevance to other research, and any recommendations for future work. Non-standard methodologies should be described and justified.

5.6 Archiving and Data Management

5.6.1 Biological remains, associated data and related documentation should all be incorporated into the overall project archive, which will be deposited with the appropriate repository. All archive material should be stable and accessible, in line with published guidelines (Brown 2011; Perrin et al 2014; CIfA 2020c). The digital archive component should contain all born digital material, i.e. material created by digital means as opposed to on paper), and some secondary digitised material (including codes, electronic files of data and metadata, and text files, diagrams, photos), and be fully documented and indexed (Brown 2011, 18; Archaeology Data Service 2020).

5.6.2 Archives of human remains are intensively used by researchers, so retention of the human remains for future research is key to mitigating the impact of development on ancient cemetery sites. Secular law is permissive toward retention of human remains in museums, and public opinion is generally supportive of this. Storage should conform to existing standards (http://webarchive.nationalarchives.gov.uk/+/http://www.culture.gov.uk/images/publications/GuidanceHumanRemains11Oct.pdf). Ecclesiastical Law generally stipulates reburial.

5.6.3 In the first instance the environmental material recovered should be considered for museum archiving on an equal footing with other forms of archaeological material recovered during the project. This is to allow for the possibility of the application of analytical techniques such as isotope analysis, or ancient DNA analysis, and allowing for the future improvement and refinement of these techniques. A summary of the archived data should include a sufficient description of what is in the archive, in order to enable future researchers to decide whether or not these data are relevant to their investigation.

5.6.4 No decision on disposal of material generated by a project should be taken until formal agreement with relevant stakeholders. In such cases the full details of the disposed material should be documented.

5.6.5 In preparing the archive, specific material (of limited significance, that doesn't contribute to current or future understanding) may be chosen for deselection and discard. Decisions on selection should be set out in the selection strategy and be reached as a result of consultation with relevant stakeholders, see https://www.archaeologists.net/selection-toolkit for more information

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Case studies for the Environmental Archaeology Guidelines

Four of the original Case Studies that will be retained from the 2011 Guidance (to view these case studies refer to the Environmental Archaeology Guidance, 2nd edition on the Historic England website).

In addition, there are four new cast studies. Through the main text of the Environmental Archaeology Guidance the previous case studies have retained their old numbering, while reference to the new case studies have been labelled A-D. In the final version these will all be renumbered.

Case study 1:

Consequences of not assessing all the samples taken for the recovery of charred plant remains

Case study 2:

Fit for purpose: a fishy tale from Chester that matches aims, methods and site

Case study 4:

Sampling for charred plant remains: the importance of considering context type and the archaeological period being investigated

Case study 6:

Multidisciplinary sampling in the intertidal zone at Goldcliff East, Gwent Levels, Severn Estuary

New case studies

Case Study A

Environmental Archaeology and Artefactual Recovery: The Pewsey Hoard

Ruth Pelling (Historic England)

A late Roman copper alloy vessel hoard found by metal detectorists in the Vale of Pewsey, Wilshire, contained exceptionally well-preserved plant remains enabling the reconstruction of the packing and burial history of the hoard. The hoard consisted of a series of stacked and covered bowls and cauldron, with four pan scales in the interior. Leaves, stems and flower heads were clearly visible within the interior of the hoard. The sediment within and between the vessels was sieved and sorted for macroscopic plant remains, while samples were carefully scraped from the corrosion salts on the surfaces of the various vessels for the analysis of microscopic remains (pollen and fern spores).

Metal corrosion salts can impregnate organic material in contact with the corroding metal and act as a natural biocide inhibiting attack by micro-organisms and fungi in the soil. While textile or plant fibres are often seen within the surface corrosion of copper alloy or iron objects, a void within the interior of the Pewsey hoard had resulted in the preservation of loose plant material. Flowers, seeds, stem and leaf fragments were completely desiccated, some encrusted with green, blue-grey or grey to white metallic deposits. XRF examination detected both lead and copper. Enough carbon had preserved in one flowerhead and some stems to enable C14 dating.

Pollen, spores and macrofossils from the interior of the hoard indicate that is was likely packed in mid-late summer, using bracken and grassland vegetation to wrap the pan scales, and buried by early autumn. The grassland exploited was likely long-established supporting betony, devil's bit scabious (represented only by pollen) and vetches. Knapweed and bracken were the best represented of the larger plant items, but poorly present in the pollen/spore samples. The vessels were probably packed in an area of mixed landscape with calcareous grassland, arable fields likely surrounding the settlement, with some background of woodland edge and heather from more acidic heathland soils. Modern cereal remains in the outer vessel, a cauldron, either indicate that the hoard was buried in an arable field or derive from the recent arable environment from which the hoard was recovered.

While the preservation of flower heads and bracken fonds was exceptional, it was the combination of both pollen and macrofossil evidence, including dating, that enabled such a detail reconstruction. Importantly, no treatment or cleaning had been conducted prior to submission to the Portable Antiquities Scheme, and the scientists involved were able to sample the vessels and accompanying sediment together. For further reading see Henry et al 2019.

Henry, R., Roberts, D., Grant, M., Pelling, R., & Marshall, P. (2019). A Contextual Analysis of the Late Roman Pewsey and Wilcot Vessel Hoards, Wiltshire. *Britannia, 50*, 149-184.

Figure 1: Flower heads from within the Pewsey hoard

Case Study B:
The Norfolk Projects: Embedding environmental archaeology into submerged landscape assessments for offshore wind farms.

Claire Mellett and Victoria Boothby (Royal HaskoningDHV)

Site and background

Norfolk Boreas, Norfolk Vanguard East and Norfolk Vanguard West (collectively the Norfolk Projects) are located in the southern North Sea, approximately 50 km off the coast of Norfolk. The export cables connecting the offshore array to the national grid, make landfall at Happisburgh - one of the earliest Lower Palaeolithic sites in Britain.

The identification and investigation of prehistoric archaeology offshore can be challenging. Within the offshore boundaries of the Norfolk Projects water depths reach up to 50 m and the sub-surface geology is buried beneath sand waves up to 5 m high in places. The approach to environmental archaeology in these inaccessible contexts requires an almost entirely different approach. It is not simply a case of translating strategies used onshore, into the marine environment.

The following case study demonstrates how, through cross-discipline collaboration, an approach has been developed which embeds the environmental archaeology objectives within submerged landscape assessments for offshore wind farms.

Offshore survey

Marine geophysical survey data underpins submerged landscape assessments and is used to identify and map landscape features such as palaeochannels and palaeoshorelines at the seabed and in the sub-surface. Bathymetric data from the Norfolk Boreas Project provided the first hint that palaeochannel features were present (Image 1). However, upon assessment of sub-bottom profiler data, an extensive palaeochannel network was revealed indicating a high potential for preservation of alluvial or floodplain deposits, including peat.

Geomorphological assessment of the marine geophysical survey data provided the palaeogeographic context to understand the extent and preservation potential of submerged prehistoric landscapes across the Norfolk Projects. However, it was through marine geotechnical surveys that sediment samples from contexts of archaeological interest were recovered to ground truth these geophysical interpretations and provide the physical material that could be assessed for environmental remains.

Considering the high costs of marine survey vessels, particularly those large enough to undertake geotechnical surveys, it is not sustainable to undertake separate geotechnical surveys for geoarchaeological purposes on offshore wind farm projects. Therefore, collaboration between geotechnical engineers and marine geoarchaeologists is vital to ensure the archaeological objectives are embedded in the geotechnical survey programme from the very early stages of a project. The archaeological assessment runs alongside the development processes and is not an afterthought which speeds up the delivery of both the archaeological and engineering objectives.

Assessment strategy

Once core samples were acquired for the Norfolk Projects, a full suite of multi-proxy palaeoenvironmental and dating techniques were applied to sub-samples from peat and minerogenic deposits. An assessment of macroscopic plant, pollen, foraminifera, ostracod and diatom remains was undertaken. Preservation and concentrations were sufficient to undertake full analysis of all remains, except for diatoms which were poorly preserved, likely due to post-depositional processes. In total, nine new palaeoenvironmental records were produced from two key periods – the transition from Late Palaeolithic to Early Mesolithic and Middle to Upper Palaeolithic. The palaeoenvironmental analysis was supported by radiocarbon and luminescence dating.

Research questions

It is typical to define research objectives and questions prior to undertaking any palaeoenvironmental assessment, building on previous work undertaken locally or in similar contexts, and drawing on regional or period specific research agendas. There were no known archaeological or palaeoenvironmental records from the area of seabed covered by the Norfolk Projects (with the exception of the nearshore section of the cable corridor at Happisburgh - see below). Therefore, during the early stages of the geoarchaeological assessment, the research objective was very broad - *Identify submerged landscape features and develop a stratigraphic framework to understand archaeological potential*. By the final stages of the project, the research questions were significantly refined towards understanding landscape evolution, vegetation history, palaeogeography and the timing and nature of landscape inundation.

This was achieved through an iterative process. Each time a new geotechnical survey was undertaken, the logs were reviewed, samples from deposits of archaeological interest were retained, and the stratigraphy/deposit model was updated. The approach to palaeoenvironmental investigations was staged and included an initial assessment of the suitability of a range of multi-proxy techniques and the development of a skeleton chronological framework. This was supplemented by full, high-resolution analysis of proxies with additional dating to provide a robust Bayesian chronology. At each of these stages, the research questions were revisited and refined to narrow uncertainty and allow any future work to be targeted. This made the processes manageable and sustainable, considering the temporal and spatial scale of the investigations, and provided a degree of flexibility to maximise the outcomes of the assessment.

Correlating geoarchaeology onshore and offshore

Typically, geoarchaeological assessments for the onshore and offshore portions of offshore wind farm cable routes are undertaken independently due to the different planning requirements. However, given the archaeological significance of the deposits preserved at Happisburgh, a more integrated approach was adopted for the Norfolk Projects.

Terrestrial and marine geoarchaeologists worked collaboratively to ensure the investigations being undertaken in the nearshore and coastal zone were complementary. This included reviewing and correlating stratigraphy across the land-ocean interface to create a seamless deposit model. The same palaeoenvironmental techniques (and specialists) were used for the marine and terrestrial assessments to ensure consistency in methodologies and reporting.

Engagement with academic researchers was also a priority to maximise the research outputs from the project. Researchers at the University of Southampton provided input into the nearshore geotechnical survey design and provisions were made to share samples recovered for academic research. This was all facilitated by the developer (Vattenfall) who supported collaborative working between different elements within the Project teams, but also with the wider academic community.

Highlights and next steps

The geoarchaeological and palaeoenvironmental assessments undertaken to support the Norfolk Projects identified an area of prehistoric peat/wetland covering up to 85 km^2 of the seabed. This is arguably one of the most extensive, intact palaeolandscapes identified to date in UK waters. The palaeoenvironmental investigation has provided 14 new luminescence dates and 15 new radiocarbon dates, almost doubling the number of dates available from offshore contexts in the southern North Sea. It also provided four new pollen sequences, bridging the gap between British and continental pollen datasets for the Early Holocene. A new sea-level index point was produced improving understanding of the timing and nature of inundation of the North Sea. Publication of the assessment reports as open access as part of the planning process ensured outputs were timely and transparent. Ongoing assessment will address outstanding research questions, culminating with publication in peer-reviewed academic journals.

Across the full extent of the Norfolk Projects, nearly one million years of human history has been investigated, from the earliest record of human activity in Britain at the landfall near Happisburgh, to final inundation of the North Sea during the Early Mesolithic. The sustainable, collaborative, iterative and flexible approaches outlined here have maximised the geoarchaeological and palaeoenvironmental outcomes from the Norfolk Projects, providing a new baseline and archaeological context to inform submerged landscape research in the southern North Sea.

Considering the scale of upcoming offshore wind development, adopting a similar but proportionate approach to other offshore wind projects will significantly advance the number and quality of palaeoenvironmental and chronological records from submerged contexts

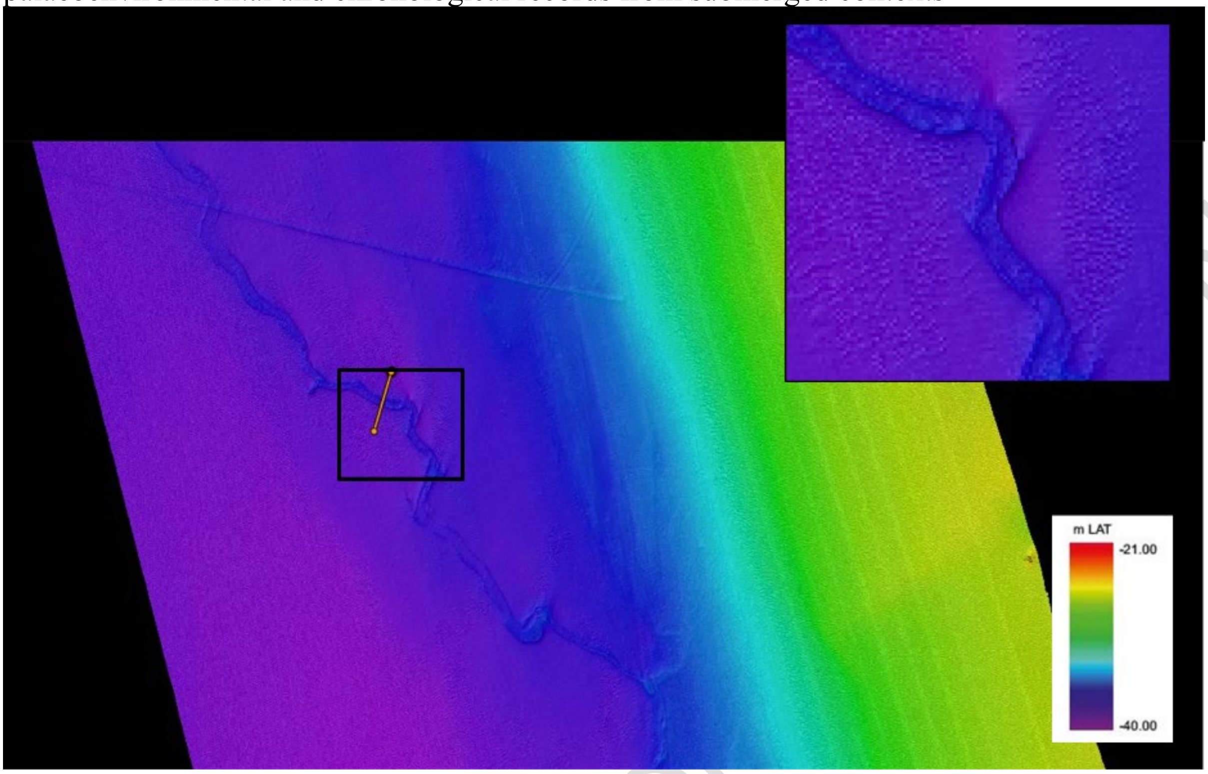

Figure 1: Bathymetry indicating palaeochannel preserved at seabed

Case Study C
Environmental Sampling on Archaeological Watching Briefs
Don O'Meara (Historic England), David Jackson (Wardell Armstrong Archaeology)
During an archaeological watching-brief for the installation of a utilities pipe north-east of Carlisle a series of pits and a larger structure were observed. These were archaeologically cleaned and prepared for recording. The presence of fired daub suggested the larger structure might be a corn drying oven or kiln. The archaeological investigation of these features included the taking of flotation samples from the features. The presence of Roman pottery and the proximity of Hadrian's Wall to the north initially suggested this was a Roman structure.
16 samples were taken and produced low numbers of wheat, rye and barley grains, as well as over 2,000 oat grains (mainly from what was now evidently a corn-drying oven bowl). Though the identified artefacts were all Roman an archaeobotanical assemblage of this nature would more typically be found from a medieval context in this region. A radiocarbon date from the oat grains was sought, and produced a date of AD 1033-1207. The results of this investigation were later published in the local archaeological journal.
The environmental samples from this project:

- confirmed the use of the structure as a corn drying oven,
- suggested an alternative date to the one suggested by the initial artefactual evidence
- provided the material for the radiocarbon date to confirm the medieval origins.

It was important for this project that the client was briefed that environmental samples might be taken as part of the fieldwork, and agreement on the costs of analysis and possible radiocarbon dates was clear. The publication in the local journal also meant the results of this project would be disseminated as an open access publication.
Jackson, D., O'Meara, D. and Stoakley, M. 2015 Land at Low Crosby, Cumbria: Results of an Archaeological Watching Brief. *Transactions of the Cumberland and Westmoreland Antiquarian and Archaeological Society*, 29-44

Case Study D
Creating project specific Written Schemes of Investigation
Don O'Meara (Historic England), Jim McQueen (BWB Consulting)
Iron Age sites in the lowlands of North East England are characterised by concentrations of circular ring-gully features, often surrounded by deeper enclosure ditches and shallow linear features. The nature of these remains means research is often best advanced by the stripping of large areas of ground – an activity in North East England that is most often associated with house building or surface mining. The study of these sites was greatly advanced by the advent of PPG16 in 1990, and by later iterations of local government planning.
The phasing of these sites was developed through the 1990s, and particularly by archaeological work in advance of mining and house building activity north of Newcastle from 2002-2008 (Hodgson et al 2012), and subsequent publications. Though an understanding of the nature and form of these settlements developed in this period, the sites remained typically artefact poor. Pottery assemblages tend to be small, and of a type which is poorly diagnostic, and metalwork of any kind is rare. The evidence from environmental archaeology also tends to be comparatively poor, with low densities of charred plant remains and poor bone survival, the latter as a result of the acidic free draining soils.
In 2017 archaeological remains were revealed during the preconstruction work for housing development at Burdon Lane, Ryhope, near Sunderland. The form of the features revealed them to be typical the Iron Age in North East England. Discussions between the archaeological consultant for the developer, the local authority archaeologist from Tyne and Wear Archaeology, and the Historic England Science Advisor focused on creating a site specific WSI to address the regional research framework and also acknowledge the limitations of sites of this nature and the experience of other projects. In 2020 during the preparation of the WSI the stakeholders had access to a geophysical survey and an evaluation report.
Using these documents and a broader knowledge of comparable sites the premise of the WSI was:

- Deposits were expected to be well drained and acidic;
- The types of biological remains and artefacts present would be similar to other comparable sites in the region;
- Material suitable for radiocarbon dating would not be present in all contexts;
- The broad pattern of settlement seen in comparable sites (with a division between the early, mid and late Iron Age) would be applicable here;

On this basis the WSI focused on:

- Accepting that bone preservation would likely be poor and mainly restricted to lose teeth;
- Preservation of plant material would largely be in the form of charred remains;
- The dating of the site needed to be placed within a Bayesian framework, and not be wholly reliant on radiocarbon dating of charred plant remains;

The WSI did not focus on sampling every context with a 40-60 litre flotation sample as enough data was available from other sites in the region to show this was not productive. Instead, the sampling and recovery strategy focused on:

1. Sampling the termini of ring-gullies, on pits and hearths associated with the roundhouses, on the primary fills of enclosure ditch termini.
2. Not sampling from the upper fills of ditches and from shallow linear features unless unexpected remains were identified.
3. Taking OSL samples from all enclosure ditches and retaining these for consideration at the post-excavation stage when the Updated Project Design was being prepared.

4. Committing to the utilisation of stable isotope analysis for the charred cereal grains and organic residue analysis for the pottery with the aim of advancing regional agendas for the Iron Age

This sampling and recovery strategy greatly reduced the number of samples taken overall while focusing resource on areas of the site which were thought likely to be most productive. At the same time it used techniques which would develop our understanding of this common site type overall. It was flexible to allow for unexpected scenarios (such as the presence of waterlogged preservation, unexpected preservation of deposits of animal bone, or human burials from any period), but also created an agreed hierarchy of sampling for typical contexts.

The WSI was negotiated as a compromise between the needs of the project to use resources to greatest effect and reduced potential wasted outlay, while also adhering to the needs of the development to not only record the archaeological resource but to advance our understanding of that resource (NPPF para. 205)

Regionally the project aimed to build upon previous work and to encourage the use of novel approaches and techniques. It was appreciated that this form of prehistoric settlement is relatively commonly encountered in the region and that future projects would be able to further refine and adapt the approach taken at Burdon Lane.

Hodgson, N. McKelvey, J. and Muncaster, W. 2012 The Iron Age of the Northumberland Coastal Plain. Tyne and Wear Archives and Museums Archaeological Monograph.

Appendix 1: Introduction

This appendix is intended to support archaeological project managers, local authority archaeologists, and archaeological consultants in understanding the key relevant information for the main specialisms employed in archaeology in England today. They do not cover every archaeological science application that can be applied to the archaeological resource but cover the most commonly used methods and approaches.

From the outset there have been examples of individuals using the earth sciences or biological sciences to study archaeological remains associated with past human activity. Well known examples of this include the use of zoology anatomy by William Buckland to identify the bones of extinct mammals in caves in Kirkdale Cavern, Yorkshire in 1822, the use of geological sciences to propose ancient dates for Palaeolithic tools by John Frere in 1797, or the use of pollen studies by Harry Godwin from 1940 onwards to propose changing landscapes and environments through time. Over time, and particularly from the 1960s onwards these methods developed into the distinct field of environmental archaeology, which itself has undergone further evolution.

In England the incorporation of archaeology into the planning system from 1990 (known as Planning Policy Guidance 16: Archaeology and Planning, or PPG16), and the increase in archaeological work this generated, resulted in a boom in developer funded/commercial environmental archaeology services. This not only opened up employment opportunities for archaeological scientists but also created datasets which challenged academic paradigms, leading to refinements and improvements in archaeological science methodology. This mutual support and development between academic and developer funded research continues to this day.

Today many commercial archaeology units have at least one environmental specialist – typically with a background in zooarchaeology or archaeobotany. Many units have several individuals with a range of specialist skills depending on the nature of the region in which they work and the size of projects they may be undertaking. These individuals may also be responsible for associated tasks such as co-ordinating the outsourcing of specialist analysis or taking a lead in the choice of materials for radiocarbon dating.

Developments in archaeological science, and the increasing complexity of the approaches and methods used to study archaeological remains has also meant where once a single specialist might reasonably undertake different strands of work there is now often the need to consult multiple individuals with distinct specialist skills. For example, the field of archaeobotany can encompass work on charred plant remains (typically seeds and cereal grains), waterlogged macroscopic remains (which can include delicate preserved vegetative remains), charcoal, and waterlogged wood. Within the broad field of archaeobotany these areas all exist as discreet fields of study in their own right, with their own distinct approaches to sampling, identification, quantification and analysis. Similarly, zooarchaeological assemblages of diverse remains of fish bone or bird bones may present identification and quantification challenges beyond those seen in mammal bone assemblages from the same site.

In all cases it is the responsibility of the specialist to be clear where they may need to seek the input of additional support in order to properly address the research potential of the material they are working on. Likewise, project managers should ensure all staff are suitably experienced to undertake their work assigned to them, and have the skills, knowledge and experience required.

The increasing sub-specialism within environmental archaeology does not mean that individuals cannot cross sub-specialist boundaries. However, it does mean that all practitioners need to stay aware of new developments within their fields, engage in Continuous Professional Development (CPD), and understand when they may need to call upon experienced peers, or utilise resources such as specialist reference collections to help them complete their work to a high professional standard. There are also a number of Special Interest Groups that provide supported environments for CPD and for networking. These groups are particularly important for those working as sole traders or in small units where they may be the only environmental archaeologist employed by their organisation. For all archaeological projects it is recommended that early contact is made with an experienced specialist to discuss the sampling and recovery of biological remains. In addition, there needs to be clarity as to what sorts of outputs are needed or are possible for the project. This can include all stakeholders being clear on:

- The resources required for assessment or full analysis,
- The different outputs between assessments or full analysis,
- What resources may be required for publication of results,
- What resources may be required for the production of FAIR datasets/ archives,
- How specialist input may address project specific, regional, and national research agendas,
- Whether further sub-specialist input is required for the successful completion of the project,

The following sections have been arranged in an easily comparable short format. This is presented as:

1. Introduction: a summary of the biological remains
2. Preservation: the key preservation conditions and site types where the biological remains may be found
3. Recovery: a summary of the method of recovery and recommended sample volume
4. Archaeological significance: some of the key archaeological questions which may be answered by the remains.

Recommended reading has also been provided and where possible this has included open access publications.
Further information on these and other archaeological techniques can be sought from the Historic England Science Advisors.

Multi-proxy approaches
The use of multiple lines of evidence to study archaeological sites and environments is now well established. Some of these multi-proxy approaches work well because the different biological remains may be preserved under similar conditions and in similar archaeological contexts. For example, a medieval latrine fill could usefully be studied with a combinations of macro-plant archaeobotanical analysis, pollen analysis, insect analysis and parasite analysis. In other situations the different lines of evidence can be combined because the biological remains preserve under different conditions and thus should one element be poorly preserved this may be compensated by others. This is why studies in estuarine environments may utilise diatoms, ostracods and foraminifera.
In cases where multi-proxy approaches are considered this requires careful co-ordination of specialists, and an understanding by all project stakeholders how the outcomes of different studies will contribute to the aims and objectives of the project.

01 Mammal bone

Introduction Mammal bone is found on archaeological sites from all periods – from the earliest stages of human evolution to the modern period. Its study is integral to research into patterns of hunting, domestication, changing economies and craft work. On some sites, particularly with urban deposits, mammal bone may be the most commonly occurring archaeological material. Thus, for project planning it is important to consider appropriate sampling and recovery strategies, as well as later assessment and full analysis. The effective recovery of fish bone and bird bone require their own recovery strategies and are covered in sections 02 and 03 of this Appendix	Preservation Bone is best preserved in deposits that are pH alkaline to neutral. In England these environments are more common in the east Midlands and south-central areas. However, local site formation can create environments conducive to bone preservation in any part of the country. In urban areas characterised by Roman, medieval and post-medieval archaeology waterlogging as well as local preservation conditions caused by human activity can lead increased levels of preservation. In rural areas middens (particularly shell middens) can create localised conditions which allow for excellent bone preservation in regions with otherwise poor levels of bone preservation. This can occur even where most of the shell has degraded away.
Recovery It is important to remember that hand collection of mammal bone will lead to biases in favour of larger animals, as well as the larger bones from these animals. For this reason, on-site sieving is necessary and the resources needed for this should be considered as part of project planning Animals can also be deposited whole (as burials), or as body parts (e.g. joints), and these Associated Bone Groups (ABGs) require special treatment in a comparable manner to human inhumations. Consideration should be given to how site collection strategies can help or hinder later analysis. For example; mandibles with teeth should be recovered and stored carefully to prevent teeth falling out, to allow sampling for isotope analysis to be undertaken and accurate age at death data obtained.	Archaeological Significance The significance of zooarchaeological material is relevant to thematic and period specific research questions from the Palaeolithic to the modern period. It is important at the project planning stage to consult with a zooarchaeologist who can advise on relevant and pertinent research questions that may be answered by a project. The sheer quantity of bone can be recovered requires consideration of how its collection, assessment, and analysis will be resourced within projects planning. The significance of the zooarchaeological resource is not determined solely by the size of the assemblage. Even small assemblages can be used to address previously unaddressed or poorly studied regional or period specific questions.
Bibliography • Baker, P. and Worley, F. 2019 *Animal Bones and Archaeology: Recovery to Archive*. Historic England, Swindon • Morris, J. 2011 *Investigating Animals Burials: Ritual Mundane and Beyond*, BAR 535. • O'Connor, T. 2004 *The Archaeology of Animal Bones.* The History Press. • O'Connor, T. and Sykes, N.J. 2010 *Extinctions and Invasions: A social history of British fauna*. Windgather Press.	Photo/Image

02 Fish bone

Introduction The study of fish remains from archaeological sites is a distinct and specialised field, and not merely a subset of the study of the more commonly occurring mammal bone. The volume of fish consumption and the types of fish being consumed varies greatly between different archaeological periods. Thus, fish bone assemblages play an import role in research on social and economic changes from prehistory to the modern period. The capture, processing, transport, and consumption of fish also requires a range of technologies (particularly maritime technological developments) and patterns of activity. Archaeological fish bone studies play an import part in these studies.	Preservation Fish bone is best preserved in neutral to alkali sediments, and on sites with waterlogging and/or anoxic preservation. Midden deposits, and urban pit and well deposits also frequently preserve large assemblages fish bones. Bony fish (such as cod) preserve better than fish whose skeletons are composed primarily of cartilage, while other elements such a dermal denticles can be distinct finds from rays and skates. Other elements such as otoliths, dermal denticles and fish scales can also be preserved in a range of conditions. The presence of fish bone can also favour the preservation of mineral replaced remains as fish remains provide a readily available source of phosphate.
Recovery The size of fish bone means representative samples will always be best recovered via the sieving of sediments, and via sorting material from dried heavy residues – Case Study 2 from Roman Chester is an example of both the importance of sieving for fish bone, and also the importance of the correct identification of such remains. A maximum mesh size of 2mm is recommended to ensure good recovery. A 1mm mesh may be recommended to ensure good recovery of tiny fish bones. On sites where fish bone is anticipated those individuals sorting heavy residues from soil samples should be made aware of the range of biological elements which can be present.	Archaeological Significance The process of catching and processing fish can involve complex freshwater, estuarine and marine technologies such as hooks, nets, fish-traps, and various forms of vessels ranging from simple boats to complex sea going ships. Understanding where and how fish can be caught thus links to research on diet, economy and trade. Archaeological evidence can also contribute to understanding of past fish distributions, and human impacts on fish populations. The development of deep-sea fishing, inland transport of fish, and the farming of fish in artificial ponds are all of particular cultural significance.
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03 Bird bone and eggshell

Introduction Bird bone is distinct from mammal bone, being typically lighter to allow adaptations for flight. Therefore, its preservation on archaeological sites is comparatively less common. The recovery of bird bone and bird eggshell assemblages should always be regarded as significant. Bird bone assemblages can present significant research potential, but also significant complexity compared to mammal bone assemblages. The identification of wild bird remains in Britain needs to consider over 600 species, compared to just over 100 mammal species.	Preservation Like mammal bone, bird bone and eggshell is best preserved in deposits that are alkaline to pH neutral either naturally, or due to the alteration of deposits by human activity – such as in sites with deep stratigraphy or via the local preservation by middens. In addition, where mineral-replaced preservation is encountered, eggshell is often well preserved.
Recovery Bird bone is best recovered by sieving of deposits. Hand collection will invariably lead to biases in favour of the larger bones from larger species. Recommended sieve sizes can range from 1-4mm, depending on the type of site, and the nature of the remains being recovered. In cases where whole or partial bird skeletons are identified these should be treated as Associated Bone Groups (see Section 01 above) recovered and bagged whole and not mixed with the general assemblage. Eggshell may be recovered from the heavy residues of sieved samples and also from flots. If eggshell is observed during excavation it should be treated as one would treat a delicate artefact, recovered with its surrounding sediment.	Archaeological Significance Though within the broad field of zooarchaeology the study of birds is a distinctive field of study. Human-bird interactions include the use of birds as food, as animals with significant religious symbolism, as commensal animals, as pests, and as high-status animals both as food (e.g. swan and heron in the medieval period), and as commensal (companion) animals (e.g. the various birds of prey kept for hawking). Bird bones from archaeological sites can also play a significant role in the modern conservation studies of contemporary bird populations. The study of eggshell is important for understanding how domestic bird populations were managed for their meat and/or eggs.
Bibliography • Baker, P. and Worley, F. 2019 *Animal Bones and Archaeology: Recovery to Archive*. Historic England, Swindon • Maltby, M. et al 2018 Counting Roman chickens: Multidisciplinary approaches to human-chicken interactions in Roman Britain. *Journal of Archaeological Science: Reports*, Vol. 19, 1003-1015. • Serjeantson, D. 2009 *Birds*. Cambridge Manuals in Archaeology, Cambridge University Press	Photo/Image

04 Marine shell

Introduction Marine shells can be found on a range of archaeological sites. For inland sites, particularly from Roman and medieval sites, the presence of European flat oyster (*Ostrea edulis*) is a common and noticeable find due to their size and colour. Other species which form part of this group are limpets, whelks, dig-whelks and razor shells. Sea urchins are often included under this category though these are echinoderms rather than molluscs. Sampling for shells is distinct from other classes of zooarchaeological material. Identification and analysis is a distinct specialist skill and an archaeomalacologist should be consulted when significant deposits are encountered.	Preservation Like animal bones, marine shells will be best preserved in deposits that are pH alkaline to neutral. However, large deposits of shell in otherwise acidic sediments can create localised preservation conditions which support the preservation of shells, as well as other materials such as animal bones and artefacts. The preservation of shells in either shell rich deposits (such as middens) or as scattered finds present across a site will require different collection approaches that minimise the breakage of the shells, as well as different approaches to the sorts of archaeological questions these different assemblages can answer.
Recovery When sampling marine shells limiting collection to hand-recovery does not provide useful results. Deposits that are rich in shells (for example middens) should not be treated as a homogenous mass. Large deposits may need to be gridded, with layers collected in discreet spits (5-10cm thick). In other cases, shell rich deposits can be sampled with whole-earth samples (20-50 litres – ideally enough for 200-600 shells) The approaches to shell recovery depend on the rarity of such deposits (high significance should be given to prehistoric and early medieval assemblages), and the density of shells (shell poor deposits from Roman and later medieval sites have less archaeological significance)	Archaeological Significance The consumption of marine invertebrates occurs in all archaeological periods. However, there is a noticeable global increase in midden deposits from the mid-Holocene. The reasons for this are not fully understood, but rising sea-levels may have been a factor. The consumption of marine shellfish at sites distant from the coast may be linked to high status or elite dining, particularly in the Roman and medieval periods. As well as food consumption marine shell can be used as a raw material for artefacts or be symbolically important e.g. finds of scallop shells from medieval graves reflecting the pilgrimage of St James. They can also be used in construction, including the production of mortars.
Bibliography • Allen, M.J. (ed.) 2017 *Molluscs in Archaeology: methods, approaches and applications* (Oxbow Studying Scientific Archaeology No. 3). Oxford: Oxbow Books. • Campbell, G. E. 2023 Collecting and Processing Archaeological Shellfish Remains. BAJR Guide 56 • Campbell, G.E. 2017 The collection, processing, and curation of archaeological marine shells, pp. 273-288. In Allen 2017	Photo/Image

05 Land and Freshwater molluscs

Introduction

The garden snail is probably the most common way people encounter land snails. However, there are over 100 species of land and freshwater molluscs in Britain, many of which are only a few millimetres in length, and most of which are difficult to spot in the wild.

Molluscs build straight or coiled shells (gastropods) or paired shells (bivalves),and live in a wide range of conditions in water (fresh, brackish and salt) and on land. Each part of the land and coast usually has a characteristic range of snail species, and some species live only in specific conditions (such as damp woodland, short-turfed grassland, and brackish channels). This makes these remains very useful for reconstructing past environments, especially as they preserve well in deposits where pollen preservation is poor.

Preservation

Shells normally preserve well in regions where the underlying rock produces neutral or alkaline soils and in waterlogged deposits. They rarely survive in regions with more acidic soils, where pollen is generally well preserved, and conversely can be utilised in regions where pollen evidence is typically poorly preserved. Even in regions with acidic soils preservation can occur where the deposits were rendered neutral or alkaline by calcareous additions (sometimes by the shells themselves).

The concentration of molluscs within a deposit can vary greatly. Rapidly infilling deposits will contain fewer shells per volume of sediment than those that fill in over a longer period of time. Preservation normally improves with depth of burial. These factors need to be taken into account when sampling for molluscs.

Recovery

Mollusc studies for reconstructing land use and environmental change usually require specialist samples taken in vertical columns. Each sample should be minimum of 2 litres where possible Columns should be taken from multiple features across a site where available in order to gain as full a picture as possible.

Extraction of the molluscs involves drying the sediment, followed by gentle disaggregation using boiled water and a wash-over technique for the shells that float. The resultant residue is then mixed with further boiled water, sometimes with the addition of hydrogen peroxide to break up the remaining sediment.

Mollusca are commonly also recovered from archaeobotanical flots, However, these samples are unrepresentative of the total population of snails in the deposit and should not be used as an alternative to specialist mollusc samples.

Archaeological Significance

Molluscs from alluvial sequences give important information on floodplain development and regional land use change. Periglacial and tufa deposits are particularly useful in understanding environmental change during the Palaeolithic and Mesolithic periods. Mollusc studies can also trace the change in balance between woodland, ploughland and pasture in the Neolithic period. Studies from Wessex have shown that the earliest prehistoric monument were constructed in forest clearings, and subsequently later monuments were built in areas of already developed arable land. Molluscs have also been a key component to the study of colluvium associated with Bronze Age valley side cultivation.

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Photo/Image

06 Insects

Introduction	Preservation
Insects are invertebrates with a chitin exoskeleton and jointed limbs. They can be recovered with a range of other arthropods such as arachnids. Examples of insects and arachnids found archaeologically include beetles, true bugs, mites, flies, fleas, caddis flies and chironomids. Of these beetles are the most commonly found and studied. Some insect species occupy very narrow ecological and environmental niches, and this makes them particularly useful for understanding environmental changes, or niche environments on an archaeological site – e.g. distinguishing between a stable or house deposit, or between a water well and a latrine pit.	Insects are best preserved in deposits that are anoxic and fine grained, such a waterlogged silty clays or peaty deposits. Natural features such as fen and bog peat, lake sediments, palaeochannel alluvium and flood deposits may all be suitable, as well as anthropogenic structures such as pits, ditches, wells, stable and house floor deposits. The remains of insects can also be preserved through calcium phosphate mineral replacement, particularly in latrine contexts and deeper features where there is a throughput of water. Insects can also be preserved through charring though such remains are very delicate. Traces of insect infestation of wood, including their faeces (frass) preserve within charcoal.
Recovery Sampling for insects can be conducted via extraction of samples from sections, via geoarchaeological cores, or subsamples from whole earth samples. To recover enough insects for statistical analysis samples typically need to be 2-10 litres. It is best to discuss with the insect specialist in advance how much material they need to answer the project question. Extraction of the insect remains uses paraffin flotation, and most specialists will prefer to process their own samples. The maximum mesh size used in processing is 250µm. A minimum mesh size of 180µm is needed to ensure full recovery of mites. Samples processed for waterlogged plant remains can be subsequently used to recover insects by paraffin flotation, but this should be discussed with an insect specialist in advance to ensure correct procedures are followed.	Archaeological Significance Insects provide evidence for a range of environments from the landscape level, to the context level. They are useful for general palaeoenvironmental reconstruction, for providing details of past hygiene (e.g. lice and fleas) and living conditions, and for providing evidence of crop infestation. In rural situations, they are particularly useful for showing the character of woodland, the quality of water and the occurrence of domestic animals. In urban situations with deep organic stratigraphy very detailed reconstructions can be made of human environment and living conditions. Insects are best studied alongside other environmental proxies such as macroscopic plant remains and pollen.
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07 Charred plant remains

Introduction Charred plant remains are ubiquitous on archaeological sites. This class of material can include charred seeds, grains, stems, buds and tubers. It also includes charcoal (see Section 08). Plant remains can be charred through a variety of mechanisms which can reflect cultural activities. This can include accidental burning of cereal grains in a corn-dryer, charring hazelnuts (commonly found in large number prehistoric sites), or burning resulting from catastrophic fires in houses or other structures. Deliberate burning activities can include burning of floor sweepings, and stable waste to dispose of it, and the use of animal dung or turves as fuel.	Preservation The charring process makes the organic plant material resistant to the natural chemical and biological processing that would normally degrade and destroy them. However, they are vulnerable to physical erosion (e.g. trampling). Depth of burial and the stability of their burial medium is a factor in their preservation. They may be widely dispersed within certain contexts (such as ditches), or can be concentrated within features such as pits or kilns. Dumps of burnt material or in-situ burning can also occur. These taphonomic factors need to be borne in mind when considering where and how to sample.
Recovery Charred plant remains are normally recovered in sediment samples which can typically be up to 40-60 litres, or 100% of smaller contexts. Samples should be taken from within a single context, using clean tools and a clean receptacle. It is recommended that sediment be recovered from across the different parts of the context (rather than as a single bulk). Samples from dry-land sites are usually processed by flotation, with the flot collected in a 300-micron sieve, and the heavier residue collected in a 0.5-1mm nylon mesh. They are distinct from waterlogged remains, which are dealt with in Section 09.	Archaeological Significance Charred plant remains can reveal information on the economy and local environment around an archaeological site. This is particularly important in the study of activities relating to cereal production and consumption in all periods from the Neolithic onwards. They can provide evidence of plants used as construction material (such as thatch and turves), the use of cultivated and wild plants as food for humans or fodder for domestic animals. An understanding of these remains can also provide evidence of site formation processes, including evidence for contamination and reworking.
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08 Charcoal

Introduction The presence of charcoal in a deposit may be the first indication of human activity when conducting archaeological survey or evaluation work. Charcoal forms from the incomplete burning of wood and thus can be found on any site where people have used fire or where wildfires have occurred. The cell structure of wood is identifiable in charcoal, and specialist examination can identify the wood type and a range of other archaeologically significant details. Charcoal studies play a significant role in the understanding of the organisation of domestic, industrial, and ecological processes.	Preservation Charcoal can be preserved in most sediment types, and a range of depositional environments. This can range from charcoal being present in small, fine fragments, to deposits dominated by charcoal and contain many kilos of material. If not subjected to physical stresses, charcoal (like other charred plant material) is durable and survives well in the archaeological record. However, this durability means that it can be re-worked and re-deposited within contexts. An understanding of the taphonomy of the charcoal in an assemblage is therefore essential.
Recovery Charcoal can be collected via the same flotation samples used for general archaeobotanical sampling. In some cases deposits can be sampled using a grid, such as at charcoal production sites, in or cases where burnt structures are being investigated. Charcoal analysis is conducted using high power microscopy (x10 to x400), with higher magnification required in some cases. It also requires the recording of a range of features including the presence of bark, ring curvature, and fungal hyphae. It is therefore essential that those undertaking analysis have the requisite experience or equipment for charcoal analysis.	Archaeological Significance The controlled use of fire is significant for so many activities that the study of charcoal is an important element of many archaeological sub-disciplines. Charcoal analysis can provide direct information on fuel consumption, past ecological diversity, and human management of woodlands via coppicing. As well as the use of fire as a domestic heating fuel the use of wood or charcoal to fuel metal-working sites, for producing materials like lime, or to fuel structures such as Roman bath-houses means it is an important factor in the study of many significant human economic and social processes.
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09 Waterlogged plant remains

Introduction In temperate environments plant remains on archaeological sites are most commonly preserved via charring and via waterlogging. Though complimentary these different forms of preservation generally preserve very different types of archaeobotanical and archaeological information. Waterlogged remains not only preserve seeds and grains of plants, but also the vegetative elements such as leaves, stems, and roots. This material can include plants used as flavourings, vegetable foods and dye plants that are rarely preserved through charring. Waterlogged plant remains also provide detailed evidence of different habitats from heathland to hay meadows.	Preservation Waterlogged preservation relies on the exclusion of oxygen (anoxic conditions), and thus the cessation or slowing down of the biological and chemical processes which would normally degrade and breakdown organic materials. The Roman settlement at Vindolanda, Northumberland and Anglo-Saxon and Anglo-Scandinavian deposits in York are two of England's best known examples. However, waterlogging can occur at any site, and even in apparently well drained sites the presence of waterlogged deposits in deeper ditches or pits should be anticipated.
Recovery Sampling waterlogged deposits typically involves taking samples of 5-10 litres. They also require different processing methods – typically disaggregation in water followed by washing the deposit through sieves with a mesh of 250µm (0.25mm). To recover representative numbers of larger remains such as fruit stones and wood, wet-sieving larger volumes of sediment onto a mesh size of 4mm is preferable. However, this should done in combination with sieving smaller samples down to 250µm, The resultant material must then by stored wet and kept refrigerated to prevent the growth of moulds or algae. Processing in a flot tank and drying the resultant material will irreversibly destroy the information significance of this material. The project archaeobotanical specialist must ensure they have the requisite skills and experience to study such remains.	Archaeological Significance Waterlogged plant remains will contain a range of plant species and materials not usually recovered in charred plant assemblages. From latrine contexts vegetative parts (such as onion epidermis) and cereal bran may be recovered. Dye plants such as madder, may also be recovered. Waterlogged features such as the fills of waterholes or palaeochannels provide evidence of environmental change and different natural habitats revealing how the landscape has changed over time. Such studies are always best carried out in combination with studies for other environmental proxies such as insects, molluscs, pollen and other microfossils. The study of waterlogged plant remains can also be an important factor in the assessment of preservation conditions on an archaeological site.
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10 Wood

Introduction Before the Industrial Revolution wood was probably the most widely utilised natural product in most societies as a fuel, for building, and as raw material for a wide range of objects. In England wood preserved by charring in the form of charcoal is present on most archaeological sites. Waterlogged or anoxically preserved wood is less common, but where present can form the largest artefactual element of a site (e.g. as at Vindolanda, Must Farm, Flag Fen). The sampling, conservation, and identification of this wood is treated here as a specialism in its own right. Although the analysis of wood shares many approaches used in charcoal analysis, they are distinct fields of study.	Preservation Wood can include large structural timbers as well as delicate artefacts. The resilience of this material depends on the consistent exclusion of oxygen by a fine clay/silt burial medium, a high water table, or both. The Historic England Guidance *Preserving Archaeological Remains*, and its associated case studies present a range of conditions under which wood survives. A key preservation consideration during excavation apparently well-preserved wood can be structurally unstable due to degradation at a cellular level.
Recovery On sites where wood is anticipated advance discussions with an experienced wood specialist are essential. This will ensure the collected wood is not biased by an inappropriate collection strategy and that appropriate resources are allocated for its conservation and study. It will also mean that packing and storage is suitable (wrapping tightly in cling-film/plastic is a common but inappropriate technique which can damage the cell structure). Wood type identification is conducted using high power microscopy (x10 to x400), with higher magnification required in some cases.	Archaeological Significance The archaeological significance of wood can be broadly conceptualised as structural and artefactual. As well as helping understand construction techniques structural wood from buildings, boats or bridge structures can provide dates via dendrochronology which cannot be surpassed by any other dating technique. Where artefacts are preserved they may provide insight into items which were once commonplace in a past society but which are typically not preserved. The Vindolanda writing tablets, and their impact on our understanding of Roman Britain is one example of this.
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11 Mineral Preserved and Mineral Replaced Remains

<table>
<tr>
<td>Introduction
The terms mineral replaced remains and mineral preserved remains can be easily confused but are seperate forms of archaeological preservation.
In the case of mineral replacement, the biological tissue of both plant and insect remains can be replaced by metal salts, most usually calcium phosphate.
In the case of mineral preserved remains, the material is preserved due to the toxic nature of metal corrosion products which inhibit the normal decay processes.
In both cases archaeological material is preserved in a form which is atypical of its normal appearance, and thus requires added attention to the specific conservation and identification requirements of these remains.</td>
<td>Preservation
In mineral replaced remains the conditions for preservation are often those with high phosphate content, and slightly alkaline deposits where there is a throughput of water to allow the metal salts to replace the soft tissues. Thus, deposits from latrine contexts, drains and middens can often preserve such remains.
Mineral preserved remains are the result of metal corrosion products This can be seen in the plant packing material from the Pewsey Horde (see Case Study A, and more recently evidence from the same material suggests organic residues may also be preserved by their corrosion products. Cloth, hair, wood and leather have also been preserved by mineral preservation.</td>
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<td>Recovery
Mineral replaced plant and insect remains can be recovered using flotation samples but the majority of the remains will be present in the heavy residues rather than the flots. This means that sorting of residues down to 0.5mm will be require and this additional resource should be considered as part of project planning.
Furthermore, the identification of this material is complicated by the fact the mineral replaced items may not look like typical examples of the biological organism.
For mineral preserved remains the lifting and examination of the objects should only be done under the supervision of a suitably experience conservator, least delicate remains be damaged through inappropriate cleaning.</td>
<td>Archaeological Significance
Both mineral replaced and mineral preserved remains are of archaeological significance as they can preserve material which under normal biological and physical process would degrade over time such as organic materials associated with inorganic objects (either as packing or as a element of the object itself).
In cases where midden, latrine, or drain deposits are likely to be encountered the project environmental archaeologist should be asked if they have considered the presence of mineral replaced remains in the sampling and recovery strategy.</td>
</tr>
<tr>
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12 Pollen and non-Pollen Palynomorphs

<table>
<tr>
<td>Introduction
The use of pollen to study changes in past environments is one of the oldest techniques in environmental archaeology. Palynology can be used to study plant communities at the context level, up to the site and regional level. At a broader level these studies have been combined to study national and global trends of environmental change.
Alongside pollen occur a range of biological remains which are similar in size to pollen. This includes fungal spores, testate amoebae, algae, as well as shells, cocoons and fragment of microscopic organisms. These are termed non-pollen palynomorphs (NPP's).</td>
<td>Preservation
Both pollen and NPP's are best preserved in low-oxygen, slightly acidic sediments. Deposits in low energy depositional environments (fine grained silts and clays) will also typically preserve the widest range of robust and delicate remains. Common sampling sites are peat bogs, waterlogged archaeological sites, and lake/pond sites.
At a site level pollen studies have been used to identify Roman vineyards in the Nene Valley, England, and have also been shown to identify elements of diet not evident from macro-plant studies.</td>
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<tr>
<td>Recovery
The recovery of pollen will largely depend on the question being asked. Continuous sequences in sealed containers (cores or Kubiena tins) will allow for detailed specialist subsampling under laboratory conditions. Spot samples from sections or from excavated contexts can also be undertaken depending on the project questions. These latter samples can be collected with a clean teaspoon, placed in a sealed plastic bag or vial, and kept in cool, dark storage. It is best to get recovered samples to a specialist as quickly as possible to ensure minimal degradation of biological remains.</td>
<td>Archaeological Significance
The application of pollen studies to archaeology is vast. Recent developments in the application of Fourier Transform Infrared Spectroscopy (FTIR) and Raman spectroscopy offers many new possibilities in pollen identification which will only increase the usefulness of pollen studies in archaeology. The studies of non-pollen palynomorphs is also a rapidly developing field. The different treatment methods for NPP's, the understanding as to whether a pollen study reflects the local or regional environment, and level of detail from a palynological study (the sample resolution) should all be discussed in advance of a project with a specialist.</td>
</tr>
<tr>
<td>Bibliography
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13 Phytoliths

Introduction Phytoliths are opaline silica structures found inside the cells of many species of plant, and typically 5-100 microns in length. The reasons for their formation, how they can be identified to different plant species, and how they can be used to reconstruct past environments and human activity are all on-going fields of research. Their composition and structure make them very durable in a wide variety of depositional environments. This has made them a useful field of study in regions and sites where there is poor preservation or organic plant remains.	Preservation Due to the inorganic material which makes up their structure they can be preserved in a wide variety of environments and sediment types. though in very alkali environments (those above pH 9) phytoliths are likely to be either heavily degraded or completely destroyed. Some structures such as middens and burnt mounds may be particularly well suited to phytolith preservation. The environmental and burial conditions in temperate regions such as England means samples in the order of 10 grams are recommend, rather than the typically recommended 0.5-2 grams.
Recovery Samples may be extracted from monoliths/cores, subsampled from larger whole earth samples, or may be taken as spot samples across surfaces to understand vertical and horizontal differences in activity patterns. It is recommended that decisions on sampling occur after consultation with a phytolith specialist in advance of project commencement. The extraction of phytoliths involves a series of laboratory steps which require specialist chemicals and laboratory equipment. Once extracted from the sediment the phytoliths are mounted on slides and examined using high-power microscopy (400 x).	Archaeological Significance The use of phytoliths has been a significant part of archaeobotanical research in arid, semi-arid and desert environments where the environmental stresses seem to be particularly good at encouraging the growth of phytolith structures in plants. In temperate regions, and for England generally, more research is needed before the full potential of phytoliths may be understood. In cases where charred or waterlogged remains are present their presence has been shown to compliment the evidence from macro-plant analysis.
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14 Foraminifera

Introduction Foraminifera are single celled animals which produced a calcareous shell and live in marine environments. They are typically 0.1-0.4mm in size, though larger species of benthic foraminifera are also known. They can form a significant part of the oceanic biomass and their continuous deposition in deep ocean sediments forms the basis for many Quaternary environmental reconstructions. Notably the evidence for the cycles of glaciation come from oxygen isotope studies of planktonic foraminifera. Foraminifera are particularly useful for the information they can provide concerning marine habitats such as levels and type of salt marsh.	Preservation The calcareous shells will be preserved in similar deposits to those which preserve ostracods. Their ecological limits mean foraminifera bearing sediments will usually be in coastal or fully marine environments. Fine grained, laminated deposits of clays and silts are the most suitable for sampling. Foraminifera can be an important component of ancient limestone rock and other geological deposits and therefore specialist input is needed to ensure recovered foraminifera relate directly to the archaeological time period under examination.
Recovery It is best to discuss this with a specialist to ensure samples are the right size and taken from deposits most relevant to the archaeological questions being posed. Samples are best taken in either geoarchaeological columns, cores or in sections with Kubiena tins. The extraction of foraminifera from sediments involved dissolving the sediment in warm water and washing the sediment through a series of geological sieves (down to 75-microns).	Archaeological Significance They can be used as part of multiproxy studies which utilise ostracods and diatom analysis. Foraminifera would typically, however, only be studied where it was anticipated there was a marine component to sediment. They have been used as part of studies where marine inundations have been interpreted as part of the site formation such as at the Iron Age/Roman site of Stanford Wharf, Essex and at the Palaeolithic site of Boxgrove.
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15 Diatoms

Introduction

Diatoms are microscopic algae that produce a siliceous cell wall know as a frustule. The recovery and identification of the frustule forms the basis of diatom analysis. Their environmental specificity means they can be used to provide indications of water quality and depositional environmental, such as temperature and salinity, nutrient and mineral levels, acidity and degree of oxygenation, and whether the site was periodically dried out.

Although they are most commonly found in fully aquatic environments there are many species which live in environments that are only periodically or partly wet such as soil, moss, or damp cave walls.

Preservation

The siliceous frustule is resistant to decay and can survive in most archaeological deposits. However, like phytoliths (which are made of a comparable opaline mineral), they are likely to be damaged by strongly alkali deposits.

They can survive passage through the digestive system and thus can be recovered from both animal and human coprolites.

Their resistance to decay means they can be usefully combined with both foraminifera and ostracod analysis. This multi-proxy approach may be useful to counter biases created by differential preservation and in-wash in dynamic aquatic environments.

Recovery

It is best to discuss this with a specialist to ensure samples are the right size and taken from deposits most relevant to the archaeological question being posed. Samples are best taken in either geoarchaeological columns or in sections with Kubiena tins.

The extraction of diatoms requires the use of chemicals, firstly to oxidise organic material, and then to remove carbonates before the diatoms can be mounted on slides and examined under a high-power microscopy. This can include oil immersion microscopy (600-1000x), or using a SEM.

Archaeological Significance

Because of their ubiquity, particularly in aquatic settings, diatom analysis can be considered for a range of archaeological features, particularly those associated with water such as moats, cisterns, latrines and ponds. Their use in archaeology is not limited to these features. A study from a floor deposit at the coastal Glastonbury Lake village was used to demonstrate a freshwater rather than marine origin for the clay which made up the floor. A study from Viking Iceland used diatom analysis to study turf-built structures and associated archaeological features.

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16 Ostracods

Introduction

Ostracods are small (normally ranging from 0.5-2mm) bivalve crustaceans with chitin valves that can become mineralised with low-magnesium calcite. Ostracods inhabit nearly all types of aquatic environments. This includes natural waterbodies (freshwater, brackish, and marine), as well as wholly artificial waterbodies such as ponds and moats.

Their small size, their common occurrence, and the sensitivity of different species to water conditions (temperature, pH, salinity, nutrient change) makes them applicable to a range of archaeological questions.

Preservation

Like molluscs and foraminifera, ostracods survive best in non-acidic sediment, and in finer grained sediments under waterlogged conditions. As a general rule the diversity and density of living ostracod populations are better suited to environments with standing or slow flowing water that is carbonate rich.

As ostracods live in comparable environments to diatoms and foraminifera they are best integrated with studies of these organisms to provide a holistic picture. This can be particularly useful in brackish conditions where low-density foraminifera communities occur and where there is a high probability of in-washed diatom remains.

Recovery

Samples may be taken in geoarchaeological cores, in sections using Kubeina tins, or as spot samples from archaeological contexts. In cases where a sequence of samples is being taken from an archaeological section the resolution of samples should be 10cm or less. When taking samples of this nature a minimum sample weight of 50 grams is recommended. The resultant sample is processed in a manner comparable to that for mollusc analysis, but will require a finer mesh to ensure recovery of juvenile stages of development (63-microns is recommended). Extraction and processing of samples is typically undertaken by the ostrocod specialist.

Archaeological Significance

Ostracods can be applied to a range of studies of past climates and water environments. This includes studies of water quality, changes in water salinity, as well as human impacts on lake and fluvial systems. In the latter cases this might reflect human induced erosion or settlements on or near water bodies which impact ostracod populations. Ostracods have also been used in provenance studies of pottery and construction material.

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Photo/Image

17 Parasites

Introduction

The study of parasites in archaeology can relate to a broad range of organisms which derive their nutrition from feeding on living hosts. This can include single cells protozoa, species of intestinal worms and biting insects such as fleas. However, most studies focus on the remains of different species of parasitic worms known as the helminths, which includes roundworms, tapeworms, flukes and thorny-headed worms. They can provide an insight into human and animal health from prehistory until the post-medieval period.

Preservation

Parasites are likely to be best preserved in anoxic and/or waterlogged deposits. However, they have also been recovered from well drained and sandy deposits and therefore their study can be considered for a range of sites from different archaeological periods. They may be present in any deposits where human or animal faecal waste is likely to be concentrated.

The parasites are most often found via their eggs, which are composed of a tough protein intended to protect the parasite egg during the completion of its life-cycle from host-to-host, often via contaminated food or water.

Recovery

Samples for the recovery gut parasites are small, and typically a 10-20 gram samples will be sufficient. They can be taken as spot samples from a section or layer, from within a column/monolith, or subsampled from a whole earth sample. Spot sample and samples from columns/monoliths may be more suitable as they allow for more precise stratigraphic control.

There are a number of methods used to extract the parasite remains from sediment, with the goal being to concentrate the remains so they can be mounted on a microscope slide for examination with a high-power light microscope at x400.

Archaeological Significance

Each archaeological period will have its own unique research questions which might be addressed by archaeoparasitology. Research at Must Farm demonstrated both the current earliest appearance of some parasite species, as well as demonstrating the foraging strategies of the Bronze Age population around the site.

For some periods, particularly urban medieval sites, it can be assumed that the population as a whole had widespread presence of gut parasites, and therefore research may be best focused on using molecular techniques to examine populations rather than just focusing on the presence/absence of such remains.

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18 Testate amoebae

Introduction

Testate amoebae is a term given to collectively describe a number of distinct micro-organisms which construct protective structures or 'tests' around their body. These tests can be siliceous, calcareous, or organic in nature. The size within this group also varies greatly, from 4-400 microns. They were initially recognised from pollen slides (as non-pollen palynomorphs -see Section 12),but have more recently emerged as a field of study in their own right. These developments have included improved taxonomic identification and using better extraction techniques which are less likely to damage the tests, compared to the harsh acid treatments used in the preparation of pollen slides.

Preservation

Testate amoebae inhabit wet environments and commonly live in the water film around soil particles, as well as on the surface of sphagnum bogs and mires. Many species have specific environmental tolerances and are particularly sensitive to water availability. They also respond to other variables, including pH and nutrient status (Payne et al 2012).

Recovery

The study of testate amoebae relies on quantifying changes in populations through time and comparing these changes to statistical ecological models which highlight the environmental variables of relevance to the study. Thus, testate amoebae studies require sampling from continuous sequences of deposits such as from a sealed core. Their sampling is usually undertaken in conjunction with sampling for pollen.

Archaeological Significance

Testate amoebae studies are most useful to study shifts in regional climatic change. This has been used in different studies to demonstrate increased regional surface wetness with corresponding implications for the human population in this area.

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