Offshore Geotechnical Investigations and Historic Environment Analysis:

Guidance for the Renewable Energy Sector

Final Report January 2011

EMU

COWRIE

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ISBN 978-0-9565843-6-6

Preferred way to cite this report:
Gribble, J. and Leather, S. for EMU Ltd. *Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector.* Commissioned by COWRIE Ltd (project reference GEOARCH-09).

Published by COWRIE Ltd.

Copies available from:
NatureBureau, 36 Kingfisher Court, Hambridge Road, Newbury RG14 5SJ, UK. Tel: 01635 550380. www.naturebureau.co.uk

Design: NatureBureau, 36 Kingfisher Court, Hambridge Road, Newbury RG14 5SJ, UK
www.naturebureau.co.uk

Printed by: Information Press, Oxford

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Executive Summary

Emu Ltd was commissioned by COWRIE Ltd to produce guidance on how best to achieve the integration of offshore geotechnical investigations and their data outputs, arising from offshore renewable energy projects, with archaeological historic environment analysis, and ensure optimum use of geotechnical data.

This guidance is specifically concerned with offshore areas likely to be affected by renewable energy projects, including the area up to the cable landfall, which is defined for the purposes of this document as the Mean Low Water Mark.

For a number of years, geotechnical data generated by offshore renewable energy projects have been archaeologically assessed as part of the environmental impact assessment (EIA) process. Although there is a broad level of consistency in the approaches to archaeological assessment of geotechnical data adopted by the archaeological community, the manner in which this assessment process has developed and become accepted within EIA requirements has meant that there are some fundamental issues that need to be addressed – in particular the integration into the geotechnical programme of archaeological assessment.

With the major site investigations that will flow from the Round 3 offshore renewable energy programme this guidance is a response to a clear need to ensure that historic environment considerations form part of the process of planning and implementing geotechnical investigations undertaken for future offshore renewable energy projects, and that data and samples from these investigations are available for archaeological assessment.

The aim of this document is to provide best practice options in relation to the integration of archaeology with offshore development-led geotechnical investigations. This will assist offshore renewable energy developers, geotechnical, archaeological and environmental consultancies and contractors, industry regulators and other authorities, and national and local historic environment curators in managing the marine historic environment during the EIA process.

The guidance therefore:

- Considers the relationship between offshore renewable energy development and the maritime historic environment, the potential physical overlap of the two, the potential impacts on the historic environment from offshore renewable energy developments, and the place of archaeology within the EIA process;
- Presents the international and national legal framework within which archaeological assessments of geotechnical data take place;
- Introduces the submerged prehistoric archaeology of the United Kingdom, places it within its geological context and considers the current state of our knowledge and understanding of this archaeological record;
- Describes the mechanics of, and reasons for, geotechnical site investigations, the equipment and methods typically used, the types of cores and samples produced, the purposes for which they are recovered, and the post-recovery testing applied to them;
- Identifies what and how archaeological material might be encountered during the course of offshore geotechnical investigations;
- Describes the relationship between geotechnical data, geophysical data and archaeology and how the use of these data in conjunction can add to our knowledge of the submerged prehistoric environment;
- Considers the role of project planning in the integration of archaeology with the geotechnical programme;
- Reviews current practice in development-led archaeological assessment of offshore geotechnical data;
- Proposes measures to ensure the effective integration of archaeological assessment into geotechnical programmes;
- Discusses how geotechnical data are currently interpreted and presented by archaeologists, and the options for archaeological modelling of geotechnical and geophysical datasets; and
- Provides recommendations for the archiving of data and the dissemination of the results of archaeological assessments of geotechnical data.

A comprehensive bibliography and reading list is included at the end of the document.

Acknowledgements

This guidance was commissioned by COWRIE Ltd. Emu Ltd would like to thank the COWRIE Secretariat at NatureBureau, particularly Eleanor Partridge and Tom Haynes, for their assistance during the production of this document.

Invaluable input and support from Dr Christopher Pater of English Heritage is gratefully acknowledged, as are the discussions with, and advice received from, Dr Martin Bates of Wales Lampeter University who provided specialist geotechnical input, particularly in the area of archaeological data modelling.

Emu Ltd would like to express its sincere thanks to the wide range of key contributors and workshop participants who gave generously of their time and knowledge in compiling this guidance, including:

Dan Atkinson, Paul Baggaley and staff at Wessex Archaeology, Peter Balson, Matt Canti, David Cotton, Simon Fitch, Ben Gearey, Alex Hale, Tony Hodgson, Andy Howard, Carolyn Heeps, Jacqui Huntley, Charlie Johns, Garry Momber, Helen Moore, Peter Murphy, Eleri Owen, Philip Robertson, Ed Salter, Jeff Sanders, Vanessa Straker, Gero Vella, Kieran Westley, Caroline Wickham-Jones, David Williams and Jim Williams.

This guidance was compiled by John Gribble with input from Stuart Leather, Dafydd Lloyd Jones and Joni Backstrom of Emu Ltd, and contributions from Martin Bates. The project was managed on behalf of Emu Ltd by John Gribble.

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- Andrew Stacey
- Emu Ltd
- Fugro Geoconsulting Ltd
- Hampshire and Wight Trust for Maritime Archaeology
- Headland Archaeology
- Marion O'Neil and the Trustees of the National Museums of Scotland
- Martin Bates
- Wessex Archaeology
- Mike Pitts/Digging Deeper Ltd

1 Introduction

1.1 In the United Kingdom (UK) the effects on the sea bed of the development of large infrastructure projects, such as offshore wind farms are dealt with through the Environmental Impact Assessment (EIA) process, which addresses the full range of receptors likely to be affected by such development, including the historic environment. An important part of the offshore historic environment is the UK's submerged prehistoric archaeological record which, as a fragile, non-renewable and finite receptor of national and international significance, requires serious consideration in the context of offshore development and EIA.

1.2 Recognising the need for interaction between sea bed developments and the historic environment COWRIE Ltd published a guidance document entitled *Historic Environment Guidance for the Offshore Renewable Energy Sector* in 2007 (COWRIE 2007) which considered the survey, appraisal and monitoring of the historic environment during offshore renewable energy projects. A second COWRIE guidance document, *Guidance for Assessment of the Cumulative Impacts on the Historic Environment from Offshore Renewable Energy,* addressed the specific issues related to the cumulative impacts of offshore renewable energy projects on the historic environment (COWRIE 2008).

Geotechnical Guidance

1.3 With the major site investigations that will flow from the Round 3 offshore renewable energy programme this third COWRIE guidance document is a response to a clear need to ensure that historic environment considerations form part of the process of planning and implementing geotechnical investigations undertaken for future offshore renewable energy projects.

1.4 This is because geotechnical data enhance our knowledge of the submerged prehistory of the UK, thereby increasing the available archaeological baseline upon which informed decisions about the impacts of sea bed development on the submerged prehistoric archaeological record can be based.

1.5 For a number of years, geotechnical data generated by offshore renewable energy projects have been archaeologically assessed as part of the EIA process for these developments and there is now a broad level of consistency in the approaches to the assessment of these data adopted by the archaeological community. However, the manner in which this assessment process has developed and become accepted within EIA requirement has meant that there are fundamental issues that need to be addressed – in particular the integration of the archaeological assessment into the geotechnical sampling and testing process.

1.6 The inclusion of archaeological considerations at all levels of the geotechnical planning, acquisition and assessment process is vital to ensure not only the cost-effective and efficient use of resources for the developer, but also to ensure optimum data collection strategies and the best use of the acquired data for archaeology. This document will provide practical guidance to developers and their geotechnical and archaeological contractors on how best to achieve this.

Figure 1 Split core samples showing sediment horizons
(courtesy of Emu Ltd)

Scope of Guidance Document

1.7 The maritime historic environment comprises a wide range of archaeological sites and materials which can be broadly divided into two main categories: on the one hand there are the material remains of human interaction with the sea, such as ship- and aircraft-wrecks and maritime infrastructure; on the other, there are submerged prehistoric sites and materials, landscapes and palaeoenvironmental remains.

1.8 This guidance is concerned primarily with the latter, as it is these materials and remains that are likely to be encountered in the course of geotechnical investigations.

1.9 This guidance:

- considers the relationship between offshore renewable energy development and the maritime historic environment, the potential physical overlap of the two, the potential impacts on the historic environment from offshore renewable energy developments, and the place of archaeology within the EIA process;
- presents the international and national legal framework within which archaeological assessments of geotechnical data take place;
- introduces the submerged prehistoric archaeology of the United Kingdom, places it within its geological context and considers the current state of our knowledge and understanding of this archaeological record;
- describes the mechanics of, and reasons for, geotechnical site investigations, the equipment and methods typically used, the types of cores and samples produced, the purposes for which they are recovered, and the post-recovery testing applied to them;
- identifies what and how archaeological material might be encountered during the course of offshore geotechnical investigations;
- describes the relationship between geotechnical data, geophysical data and archaeology and how the use of these data in conjunction can add to our knowledge of the submerged prehistoric environment;
- considers the role of project planning in the integration of archaeology with the geotechnical programme.
- reviews current practice in development-led archaeological assessment of offshore geotechnical data;
- proposes measures to ensure the effective integration of archaeological assessment into geotechnical programmes;
- discusses how geotechnical data are currently interpreted and presented by archaeologists, and the options for archaeological modelling of geotechnical and geophysical datasets; and
- provides recommendations for the archiving of data and the dissemination of the results of archaeological assessments of geotechnical data.

1.10 A comprehensive bibliography and reading list is included at the end of the document.

1.11 This document is intended to assist offshore renewable energy developers, geotechnical, archaeological and environmental consultancies and contractors, industry regulators and other authorities, and national historic environment curators.

1.12 The guidance is specifically concerned with offshore areas likely to be affected by renewable energy development, including the area up to the cable landfall, which is defined for the purposes of this document as the Mean Low Water mark (MLW). The MLW mark acts as the default terrestrial planning boundary, landward of which offshore renewable energy development is subject to terrestrial planning controls. Advice with respect to the archaeological assessment of terrestrial geotechnical data will be provided by Local Authorities.

Figure 2 Location of sites and places referred to in the text

2 Archaeology and Offshore Renewable Energy

2.1 The activities of the offshore renewable energy sector have the potential to impact submerged prehistoric archaeology. This is addressed in the EIA process, in which cultural heritage is considered a key receptor.

2.2 Direct impacts on submerged prehistoric archaeology of offshore renewable energy developments are associated, principally, with the construction phase of project and result primarily from the installation of turbine foundations and the burial of inter-array and export cables. The indirect impact of offshore renewable energy developments is the effective closure of areas of the sea bed for future archaeological or geoarchaeological investigation, or the limitation of the optimization of such investigations during the operational life of the project.

2.3 Informed decisions about the impacts of sea bed developments on the prehistoric archaeological record have to be based on adequate and reliable baseline data. Geotechnical information generated as part of the offshore renewable energy development and EIA process provides the opportunity to:

- assess the impacts of offshore renewable energy developments on the prehistoric archaeological record; and
- enhance our knowledge of the submerged prehistory of the UK, and thereby enhance the available baseline.

2.4 Enshrined in the environmental impact assessment process is the concept of sustainable development, which is defined in Defra's *Safeguarding Our Seas* (Defra 2002: 6) as the quest to ensure that 'the needs of future generations are not compromised by the actions of people today'. In relation to offshore renewable energy this implies that development should strive to be done in a sustainable way which balances the need for renewable energy with potential impacts on the offshore environment.

2.5 The application of principles of sustainable development to submerged prehistoric archaeology requires an acknowledgement that the archaeological record is finite and non-renewable, that impacts on it are permanent, that current baseline knowledge is limited, and that the renewable energy sector needs to provide data upon which informed decisions regarding the potential impacts of development on this record can be made (JNAPC 2006).

3 Zone Appraisal and Planning

3.1 Archaeology and the archaeological assessment of geotechnical data are also considered during the Zone Appraisal and Planning (ZAP), which is advocated by The Crown Estate as part of the development of Round 3 offshore renewable energy zones process (The Crown Estate 2010).

3.2 ZAP is a wide-area, strategic approach to planning offshore renewable development which grew out of The Crown Estate's decision to offer for lease large sea bed zones, within which there is potential for multiple individual wind farm projects, rather than the more tightly defined single development lease areas of Rounds 1 and 2.

3.3 Unlike the Regional Environmental Assessments (REA) being carried out by the offshore aggregate sector, the primary purpose of ZAP is to allow offshore renewable energy developers more control over the way a sea bed zone is developed, and to give them the opportunity to address environmental and planning constraints at a zone level, as part of the process of site development within the leased zones.

3.4 With respect to the historic environment ZAP will inform our understanding of the zone and guide archaeological assessments and mitigation strategies associated with individual offshore renewable energy projects. Decisions regarding the location of individual wind farms will be made on the basis of the ZAP, and these individual projects will then be subject to the EIA process as part of their consent applications and development.

3.5 The Crown Estate's ZAP Guidance can be found at: http://www.thecrownestate.co.uk/enabling-actions

4 Archaeology and Environmental Impact Assessment

4.1 There is a requirement on sea bed developers to ensure that the effects of development on archaeological heritage and landscape are considered in the EIA, and that measures are implemented to prevent, reduce and as fully as possible offset any effects.

4.2 Cultural heritage is thus a key consideration in the offshore renewable energy EIA process, but suffers from the limited extent of our knowledge of the maritime archaeological record of the UK in general. Available baseline data on submerged prehistoric archaeology are particularly thin and this limits the degree to which meaningful assessments of the impact of sea bed development on this record can be made.

4.3 In line with the draft Marine Policy Statement (see Appendix 1), opportunities provided by the offshore development process should thus be used ‘to contribute to our knowledge and understanding of our past by capturing evidence from the historic environment and making this publicly available, particularly if a heritage asset is to be lost’ (Defra 2009b: 16). It is the EIA process that ensures that this is able to happen by requiring that archaeological receptors are identified, the impacts of development on them are assessed and strategies for mitigating impacts are proposed and implemented.

5 Legal Framework – International and National

5.1 The archaeological assessment of geotechnical data in the UK is undertaken as part of the EIA process for sea bed development. The legislative framework for EIA is set by two European Directives:

- 85/337/EEC (as amended by Directive 97/11/EC) 'on the assessment of the effects of certain public and private projects on the environment', also known as the EIA Directive; and
- 2001/42/EC, the Strategic Environmental Assessment (SEA) Directive 'on the assessment of the effects of certain plans and programmes on the environment'.

EIA Directive

5.2 The EIA Directive (97/11/EC) requires an environmental impact assessment to be completed in support of an application for development consent for certain types of *project*, including offshore renewable energy projects.

5.3 Article 1 stipulates that the EIA shall 'identify, describe and assess in an appropriate manner, in the light of each individual case … the direct and indirect effects of a project on … material assets and the cultural heritage'.

5.4 The provisions of the EIA Directive have been transposed into UK legislation through various EIA Regulations, of which the following are relevant here:

- Electricity Works (Environmental Impact Assessment) (England and Wales) Regulations 2000
- Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999
- Marine Works (Environmental Impact Assessment) (Amendment) (England and Wales) Regulations 2009
- Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009.

5.5 These regulations generally take the form of secondary legislation associated with existing consent provisions in the:

- Electricity Act 1989
- Town and Country Planning Act 1990
- Food and Environment Protection Act 1985
- Planning Act 2008.

5.6 In Scotland the EIA Directive is transposed into Scottish law by the Environmental Impact Assessment (Scotland) Regulations 1999, which are in turn translated into guidance through Planning Advice Note 58.

SEA Directive

5.7 The SEA Directive requires a formal environmental assessment of certain *plans and programmes* which are likely to have significant effects on the environment, by the authorities which prepare and/or adopt such plans. Plans and programmes for which environmental assessment is mandatory under the SEA Directive include energy production.

5.8 The SEA Directive has been transposed into UK law by the Environmental Assessment of Plans and Programmes Regulations 2004. In Scotland the SEA Directive is transposed into law by the Environmental Assessment (Scotland) Act 2005, which revoked the Environmental Assessment of Plans and Programmes (Scotland) Regulations 2004. In Wales and Northern Ireland the respective SEA Regulations apply to plans and programmes which relate solely to these parts of the UK.

5.9 Since 1999 a series of joint oil and gas/renewable energy offshore SEAs have been produced by the Department of Energy and Climate Change (DECC, formerly the DTI), covering the entirety of the UK's territorial waters and continental shelf (see http://www.offshore-sea.org.uk/site/index.php for more information and copies of all SEA's produced to date). The effects on the marine environment of offshore renewable energy development have been specifically considered in the *Offshore Energy Strategic Environmental Assessment* (DECC 2009a).

5.10 In the context of this guidance, the more relevant of the two Directives is EIA, which is data-driven, scheme-specific and more detailed than SEA, which is largely desk-based and strategic. The emphasis in the EIA process is on gathering sufficient baseline information to support the production of a meaningful impact assessment for any development which considers the effects of development on cultural heritage, from individual archaeological sites to landscapes, and which proposes measures to prevent, reduce and as fully as possible offset any significant adverse effects (see Langstaff and Bond 2002).

European Landscape Convention

5.11 A third European instrument of relevance to this guidance is the Council of Europe's European Landscape Convention (ELC) (also known as the Florence Convention). This is a treaty which promotes the protection, management and planning of European landscapes and organises European co-operation on landscape issues. The Convention came into force in the UK in March 2007 and is applicable within the UK's territorial waters.

5.12 The ELC applies to the entire territory of State Parties to it, including marine areas, and defines 'landscape' as 'an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors' (Council of Europe 2000). A central aim of the Convention is the establishment and implementation by State Parties of landscape policies aimed at landscape protection, management and planning. A key measure for achieving this is landscape identification and assessment.

5.13 With a view to improving knowledge of its landscapes each State Party to the Convention is required to:

- identify its own landscapes throughout its territory;
- assess the landscapes thus identified, taking into account the particular values assigned to them by the interested parties and the population concerned
- analyse their characteristics and the forces and pressures transforming them; and
- monitor changes.

5.14 In England the requirements of the ELC have been given concrete expression through a programme of English Heritage projects, funded through the Aggregate Levy Sustainability Fund (see http://www.english-heritage.org.uk/professional/research/landscapes-and-areas/characterisation/historic-seascape-character/). The programme developed a nationally applicable method for assessing and mapping the historic character of our present coastal and marine environment – Historic Seascape Characterisation (HSC) – and extends to the coastal and marine zones the principles of Historic Landscape Characterisation already applied over much of England's land area.

5.15 Understanding the character of historical and cultural processes that have shaped the present landscapes of any area is vital for sustainable future management of the UK's coastal and marine environment. HSC will contribute to historic environment inputs into the coming system of marine spatial planning (see Appendix 1) by providing area-based representations of these historical and cultural processes and allowing their manipulation alongside other environmental databases. This is of particular relevance in light of the planned introduction of a new marine spatial planning system under the Marine and Coastal Access Act 2009.

Summary

5.16 The provisions of the EIA and SEA Directives (and their relevant national regulatory frameworks) and the Landscape Convention are clearly relevant in the relationship between offshore renewable energy development and submerged prehistoric archaeology.

5.17 As part of the EIA process the effects of sea bed development on the archaeological record and on landscape must be identified, described and assessed. Informed decisions on these effects can only be made on the basis of sufficient and reliable baseline data, for example, geotechnical and geophysical data produced during the EIA process.

6 Submerged Prehistory

6.1 It has been recognised since at least the early 20th century that in addition to shipwrecks and other maritime archaeological material, prehistoric archaeological remains are present in and on the sea bed (see Gaffney *et al*. 2007, 2009; Wenban-Smith 2002). This archaeological material is the physical manifestation of more than 800,000 years of intermittent and recurring human occupation of the UK and reflects the fact that for much of the last million years Britain was not an island (Parfitt *et al*. 2010).

6.2 For much of this time a substantial portion of what is now the UK's continental shelf and the area subject to development for offshore renewable energy, was a terrestrial landscape of fluctuating size and extent, which in the south and east of the UK formed a land bridge with the Continent (Stringer 2006). This 'lost country' not only provided routes for early humans from Europe into what is now the UK, but was also a vast, resource-rich landscape which our early ancestors could, and did, occupy and exploit (Gaffney *et al.* 2009).

Sea Level Change

6.3 The subaerial exposure of large areas of the UK's continental shelf was the product of a series of global glaciations within the last million years (Rose 2009). As global temperatures fell, water was taken up in the polar and continental ice sheets and sea levels around the world fell dramatically – by as much as 125m at certain times – exposing huge areas of the sea bed now

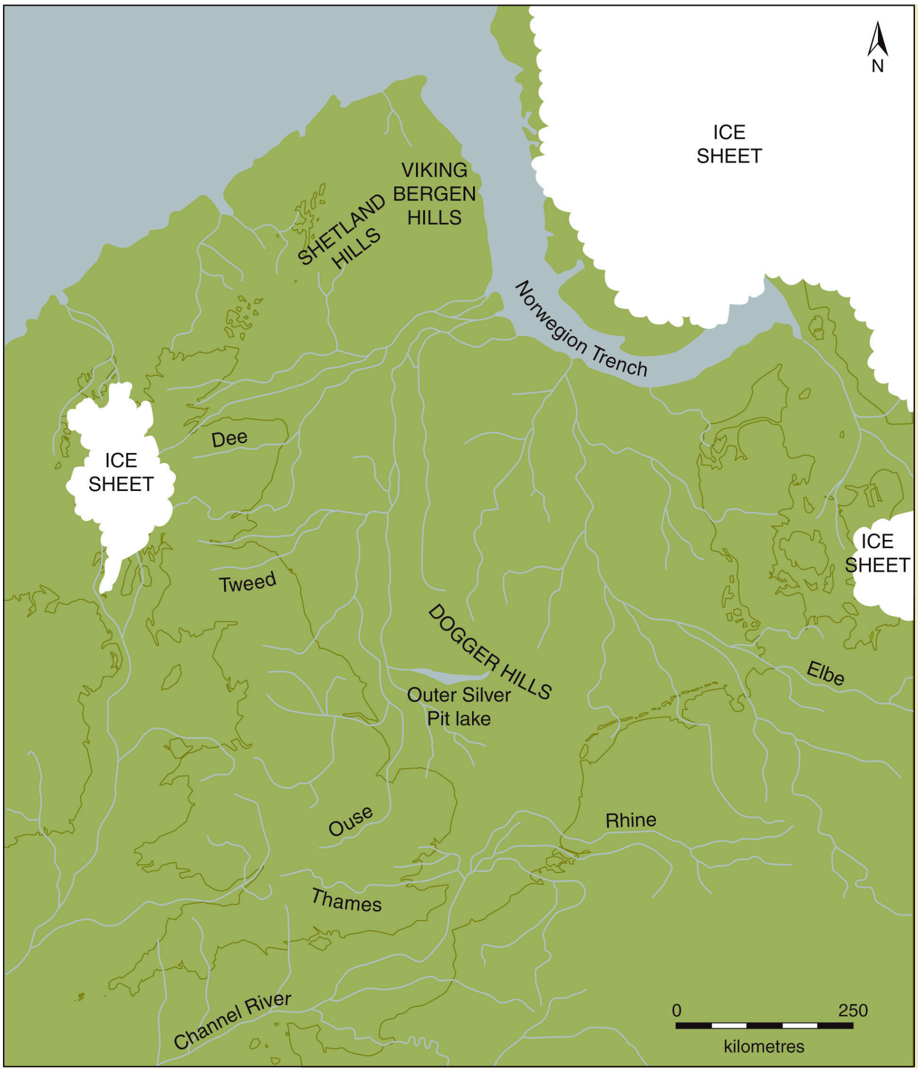


Figure 3 Extent of exposed terrestrial landscape known as Doggerland at the end of the Devensian Glaciation
(courtesy of Prof. Vince Gaffney)

being developed for offshore renewable energy for tens of thousands of years (Chappell and Shackleton 1986; Wenban-Smith 2002).

6.4 There is currently no single, definitive reconstruction of sea level change and palaeo-geography for the UK during the last million years. Bailey *et al.* (2010:4) instead point to a number of reconstructions (see for example Jelgersma (1979), Lambeck (1995), Coles (1998), Shennan *et al.* (2000; 2006), and Peltier *et al.* (2002)), all of which 'use modern sea bed bathymetry as an approximation of the past land surface, despite extensive modification (i.e. erosion or burial) since it was subaerially exposed'. This use of modern sea bed bathymetry 'is presently necessary because evidence of past land surfaces is fragmentary and contiguous shelf-scale Palaeolithic land surfaces have yet to be reconstructed' (Bailey *et al.* 2010:4).

6.5 For most of the Palaeolithic, sea levels, ice sheet configurations and palaeo-geography were biased towards glacial conditions (see Table 1) and lowered sea level and the exposure of wide areas of the UK's continental shelf was thus the norm rather than the exception. This situation would have encouraged human occupation of areas now

Table 1. Archaeological and Geological Chronology

Age in years BC/BP	British Stages	Climate	Archaeological Period	Relative Sea Level
Present day	Holocene	Warm		0m
5,500 BC			Mesolithic	-5m
				-10m
				-15m
				-20m
				-25m
7,500 BC			Early Mesolithic	-30m
10,000 BP / 8,000 BC	Loch Lomond / Younger Dryas Stadial			-35m
			Upper Palaeolithic	-40m
				-50m
10,000 BP / 7,000 BC	Loch Lomond Stadial			-60m
11,000 BP / 9,000BC	Windemere Interstadial			
13,000 BP / 11,000 BC	Dimlington Stadial			
16,000 BP / 14,000 BC	Devensian	Mainly cold		-120m
18,000 BP				
25,000 BP				-50m
50,000 BP			Middle Palaeolithic	
70,000 BP				
110,000 BP	Ipswichian	Warm		+5m
130,000 BP	Wolstonian	Cold		Low?
186,000 BP		Warm		High?
245,000 BP		Cold	Lower Palaeolithic	Low?
303,000 BP		Warm		High?
339,000 BP		Cold		
380,000 BP	Hoxnian	Warm		High?
423,000 BP	Anglian	Cold		-120m+?
478,000 BP	Cromerian Complex	Warm		Varying
500,000 BP				
860,000 BP				

covered by the sea (Bailey *et al.* 2010). In addition, these exposed areas were resource-rich lowland environments, offering access to a range of terrestrial, freshwater and coastal resources, and were therefore attractive areas for early human occupation and exploitation (Westley *et al.* 2004).

6.6 These sea level fluctuations and the palaeo-geographic changes they occasioned were the primary factor determining how much land was available for human occupation and may have influenced or constrained human movement into and within the UK (Bailey *et al.* 2010). For much of the last 500,000 years, large areas of the UK were covered by an ice sheet up to 2km thick and until 11,500 years ago the UK was 'subject to some of the most rapid and violent swings in climate and environment in the entire history of the Earth' (Stringer 2006: 8).

6.7 Perhaps the best known of the prehistoric 'lost countries' is the southern North Sea Basin, which at times in the past was a terrestrial landscape roughly the size of the UK today (Coles 1998; Gaffney *et al.* 2009). Called 'Doggerland' by Coles (1998) (see Figure 3) this was a vast, lowland plain, bisected by major rivers like the proto-Thames, Rhine, Meuse and Scheldt (Gibbard 1995), and supporting a huge animal biomass, all of which would have been attractive to early human populations. Similar drowned prehistoric landscapes of varying size and extent are known in the English Channel (Gupta *et al.* 2004; Wessex Archaeology 2008a) in the Bristol Channel, and in the Irish Sea (Fitch and Gaffney 2009).

6.8 There is thus significant potential for the survival of prehistoric archaeology either on the submerged seafloor or within sediments laid down during the periods of subaerial exposure. Furthermore, given the vast extent of the formerly subaerial landscape, the UK's known terrestrial prehistoric archaeological record only represents a component of the total record of human occupation. Consequently, there are many fundamental questions which cannot be answered using it alone, such as the antiquity of coastal and maritime adaptation or the timing and location of migration routes between the UK and Europe. The answers to many of these questions are likely to lie offshore.

6.9 After the end of the last, Devensian glaciation, sea level rose until by *c.*5,000 years ago it reached more or less its current stand and the UK was physically separated from the Continent. Although some archaeological evidence is likely to have been lost during the Holocene marine transgression, available evidence suggests that substantial amounts of data survive under and on the sea bed, from isolated prehistoric archaeological findspots to submerged sites such as that at Bouldnor Cliff in the Solent (Momber 2000) (see Box 1 over), and the relict landscapes identified in the southern North Sea already referred to, off the south coast of England and, most recently, in the Irish Sea.

Box 1. Archaeological Sites and Sea Level Change: Boxgrove and Bouldnor Cliff

Two sites from opposite ends of the UK's prehistoric archaeological time range illustrate different aspects of the relationship between archaeological sites and palaeolandscapes and past changes in sea level.

Excavation at Boxgrove (courtesy of Mike Pitts/Digging Deeper Ltd)

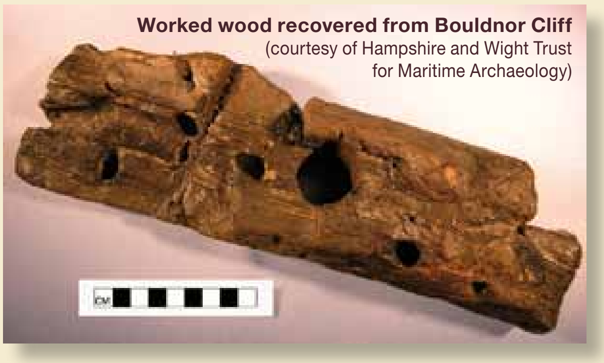
The first is **Boxgrove** in West Sussex where for many years flint handaxes were being found in the course of sand and gravel quarrying. Since 1982 archaeological excavations at the gravel pits have revealed exceptionally well-preserved primary context scatters of flint artefacts, mammalian fauna and hominid remains dating from the Middle Palaeolithic, c.500,000 years ago.

The Boxgrove sites lie at the base of a buried cliff cut into the South Downs at a time when the coast was 10km inland of its current position, the Isle of Wight was still part of the UK mainland, and the proto-Solent River flowed past the sites across the West Sussex Coastal Plain.

The handaxes referred to above are preserved above the marine sands deposited by this high sea stand at the end of a temperate interglacial period, and later archaeological material was deposited in a sediment sequence that chronicles the changing nature of the landscape and environment around Boxgrove. As the coastline retreated with the onset of the Anglian glaciation (c.478,000 BP) the beach environment gave way to a lagoon or waterhole, surrounded by salt marsh and grasslands which supported a rich faunal biomass, including rhinoceros, horse and red deer, and attracted hominids who lived off the game. Many of the animal bones excavated at Boxgrove exhibit cut marks from the flint tools used to butcher the carcasses (Stringer 2006; http://freespace.virgin.net/mi.pope/site/sitehome.htm).

The palaeolandscape of Boxgrove was subject to repeated episodes of gentle flooding. This preserved archaeological material, some of the earliest the hominin remains in Europe, and the geology of the palaeolandscape in a combination that provides a very complete picture of the coastal plain around Boxgrove as it existed half a million years ago (Stringer 2006).

Diver excavating hearth at Bouldnor Cliff (courtesy of Hampshire and Wight Trust for Maritime Archaeology)



Worked wood recovered from Bouldnor Cliff (courtesy of Hampshire and Wight Trust for Maritime Archaeology)

The second site is a Mesolithic campsite, roughly 8,500 years old, at **Bouldnor Cliff** off the north coast of the Isle of Wight. In contrast to Boxgrove, the Bouldnor Cliff site was inundated by the sea during the Holocene marine transgression and now lies 300m offshore and about 11m underwater in the Solent. The camp is located at the foot of a cliff and was occupied at a time when the Solent was dry land, following the end of the Devensian glaciation (Momber 2000).

The archaeological material is deposited within the well-preserved remains of a drowned ancient forest. The forest was discovered in the 1970s when fishermen dredged up timbers which were later dated to 6615–6395 BC (Momber 2000). The archaeological site was discovered in 1998 by divers from the Hampshire and Wight Trust for Maritime Archaeology who found flints excavated out of lobster burrows in the soft clay at the bottom of the cliff during a sea bed survey. Since then more than 300 Early to Middle Mesolithic worked flints have been found, including a large flint core and two used tranchet axes. These are associated with carbonised hazel nut fragments and oak charcoal, the bones of freshwater fish and pieces of worked timber.

Palynological analysis of sediment from the site has revealed an environment changing through time in which pine forests gradually gave way to the oak and hazel woodland associated with the archaeological site. The sedimentological characteristics of the archaeological site suggest that the habitat may originally have been a semi-stable river bar, allowing possible summer seasonal Mesolithic encampments to take advantage of local resources (http://www.hwtma.org.uk/bouldnor-cliff). The evidence then suggests that conditions gradually became wetter, with the diatom assemblage showing brackish water, salt marsh or mudflat habitat, before the inundation of the site during the last marine transgression.

7 Sediment Deposition, Preservation and Archaeological Potential

7.1 Physical processes driven by extreme climatic fluctuations during the Quaternary resulted in the formation of sediments by a variety of depositional and post-depositional processes. It is within these sediments, which are the focus of geotechnical investigations, that submerged prehistoric archaeological and palaeoenvironmental evidence is preserved.

7.2 The landscape evolution of the UK's continental shelf areas is 'complex and involves geographically varying successions of marine, lacustrine, fluviatile and glacial sedimentation and erosion' (Bailey *et al.* 2010: 8). Understanding these processes and their products is essential to interpreting prehistoric archaeological evidence, and in assessing the potential and possible archaeological significance of submerged sea bed deposits (Wenban-Smith 2002; Wessex Archaeology 2009a).

7.3 In considering submerged deposits, with their potential to contain prehistoric archaeological material, a distinction is often made between pre- and post-Devensian glaciation sediments. To a large degree this distinction is artificial, although useful in defining archaeological and palaeo-climatic periods. It reflects an assumption in submerged prehistoric studies that because of the geological and climatic processes to which they were subject, relatively little pre-Devensian sediment is likely to survive in submerged contexts on the continental shelf. In contrast, large amounts of post-Devensian sediment and, by extension, archaeological material is assumed to have survived the last marine transgression.

7.4 Recent studies indicate that material pre-dating the Devensian does in fact survive in offshore contexts and more widely than anticipated, and our current understanding of the submerged archaeology of the pre-Devensian has, and is, being rapidly transformed. The *Seabed Prehistory* project, for example, tested different methodologies for identifying prehistoric archaeological material on or within the sea bed. The project investigated a number of areas around the coast of the UK using shallow seismic, bathymetry and sidescan sonar data, geotechnical cores and benthic grab samples. The results indicated that sediments of archaeological interest of both pre- and post-Devensian age survived offshore (Wessex Archaeology 2008a).

7.5 More recently still, flint implements thought to date from *c.*100,000 years ago were recovered from aggregate dredging Area 240, off Great Yarmouth (Wessex Archaeology 2009b). These flints are possibly roughly contemporaneous with another recent find, a fragment of a Neanderthal skull, reported from Dutch waters in the southern North Sea (Hublin *et al.* 2009). Another find, which suggests the survival of material dating to the Devensian and earlier off the Humber was that of the most northerly mammoth tusk ever found in a

Figure 4 Palaeolithic flint flakes recovered from Aggregate Area 240 (courtesy of Wessex Archaeology)

marine context, recovered from Area 408 and radiocarbon dated to *c*.44,000 years ago (Dellino-Musgrave *et al*. 2009). So whilst relatively little is currently known about pre-Devensian submerged prehistory, the examples cited above suggest that more pre-Devensian sediments and archaeological material survive in offshore contexts than previously thought.

7.6 A significant factor when considering the archaeological potential of pre-Devensian sediments is the likelihood that much of the sequence is deeply buried. The acquisition of data about the depositional sequences of the Pleistocene and the sediments that make up those sequences will greatly enhance our understanding of the potential for archaeological materials to survive, and of the recent geological development of the continental shelf. Offshore studies such as those carried out for offshore renewable energy projects, which generate the data from which to build enhance the archaeological baseline thus have the potential to contribute to, and greatly expand the existing submerged prehistory knowledge base.

7.7 The prehistoric archaeological potential of submerged, sea bed sediment horizons is determined by two main factors:

- The deposition within these horizons of archaeological material as a result of human activities (for example, living sites, hunting camps, butchery sites, etc.) and any subsequent reworking of such material by other, usually natural agents (rivers, ice sheets, etc.); and
- The accretion and survival of sediments (both pre- and post-Devensian) either within which the archaeological material lies, or which protect sites and material during physical processes such as marine transgression.

7.8 The survival of sediments of prehistoric archaeological interest on the UK's continental shelf has been influenced by large scale fluvial and glacial activity driven by glacial/interglacial oscillations and marine transgressions and regressions occasioned by sea level change. The degree to which these processes impacted formerly terrestrial landscapes on the continental shelf will determine the extent to which sediments are likely to be preserved (see Hosfield 2007; Ward and Larcombe 2008; Bailey *et al.* 2010).

7.9 The submerged archaeological record may include *in situ* sites and materials which have remained in the position in which they were deposited, or archaeological material which has been entirely reworked and removed from its original position by the processes described above, and redeposited elsewhere. *In situ* and reworked assemblages are commonly referred to as primary and secondary archaeological contexts respectively.

7.10 In summarising the potential for the survival of sediments of archaeological interest dating to the last 700,000 years every indication is that there exists a rich record offshore in UK waters, and that prehistoric archaeological sites and materials should be expected to survive in some form in or on much of the UK's continental shelf.

Box 2. Prehistoric Archaeology and Geological Processes: Happisburgh and Pakefield

Recent increases in the pace of coastal erosion on the east coast of England have been instrumental in the discovery of two important Palaeolithic archaeological sites, which together have pushed back the date of the first known hominid occupation of the UK to more than 800,000 years ago (Parfitt *et al.* 2010).

The sites, near the base of eroding sea cliffs at **Happisburgh** in Norfolk and outside **Pakefield** in Suffolk, comprise organic muds and sands of the Cromer Forest-bed Formation, which were laid down in river channels and on floodplains at a time when the UK was part of continental Europe, more than half a million years ago. The deposits contain well-preserved ancient animal bones and plant remains, including tree stumps, and have been the subject of scientific interest since at least 1897 (Stringer 2006).

Excavation section at Happisburgh
(courtesy of Andrew Stacey)

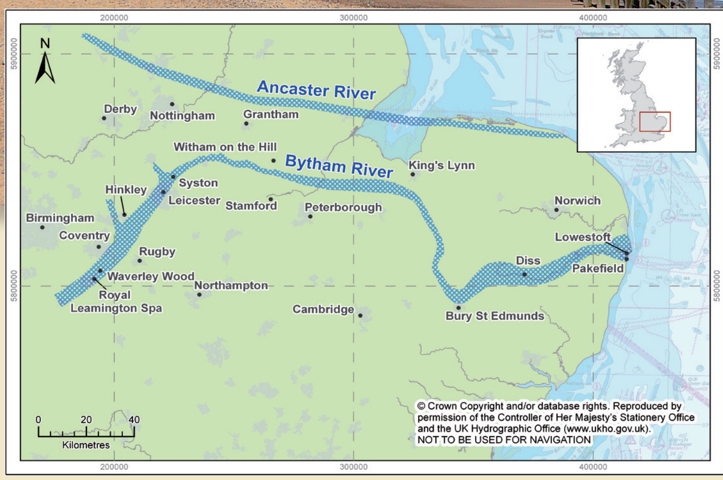
The discovery of a black flint hand axe on Happisburgh beach and the identification of cut marks left by flint tools on a 500,000 years old bison bone from Happisburgh, followed by the find of a flint flake in a Cromer Forest-bed exposure at Pakefield in 2000 were unequivocal – there were early humans in East Anglia at least half a million years ago, by far the earliest evidence for the presence of early humans in Europe north of the Alps (Parfitt *et al.* 2005). Excavations at Pakefield have since produced further flint artefacts, which have been found in four different sedimentary contexts, suggesting that humans were a regular feature of the landscape over a long period. Mammal remains and plant and insect fossils from the sites reveal a lush environment with a temperature significantly warmer than today.

Excavation at Happisburgh showing context
(courtesy of Andrew Stacey)

The survival of these fine-grained sediment deposits at Happisburgh and Pakefield, which are believed to be associated with the prehistoric Ancaster and Bytham river systems respectively, is unexpected considering their character and the geomorphological processes they have been subject to since deposition. Received wisdom was that these types of deposit did not survive the subsequent glacial processes. However, the location of these deposits at the base of the sea cliffs and on the foreshore at both Happisburgh and Pakefield suggested that it was possible that they also survived offshore.

Wessex Archaeology carried out a marine geophysical survey programme at both sites as part of the ALSF *Seabed Prehistory* project to see if it was possible to trace the fine-grained sediments offshore. Although unsuccessful at Happisburgh, the survey was able to identify the sediments off of Pakefield. Subsequent geotechnical investigations confirmed the presence of these Bytham River deposits observed in the seismic survey data (Wessex Archaeology 2008).

This work is further evidence for the survival offshore around the UK of prehistoric sediments and the archaeological material



Map showing the courses of the palaeo-Bytham and Ancaster Rivers

8 Archaeological Data and Research Agendas

8.1 In the last decade, partly as a result of sea bed developments, our understanding of submerged prehistory has expanded dramatically. There remain, however, substantial unknowns and gaps in knowledge, and despite what we do know the submerged prehistoric archaeology of the UK is still largely *terra incognita*. This section outlines the current state of submerged prehistoric archaeology in the UK, touching on recent and ongoing projects, recent finds, and the archaeological thinking that is currently driving UK submerged prehistory studies and research agendas.

What's Known

8.2 As stated already, the presence of prehistoric archaeological sites and remains on the sea bed has been known for many years. Despite this, Westley *et al.* (2004) argue that it is only in the last fifteen years that there has been a concerted effort to explore and study the submerged prehistory of the UK (see also Fischer 1995; Coles 1998; Flemming 1998).

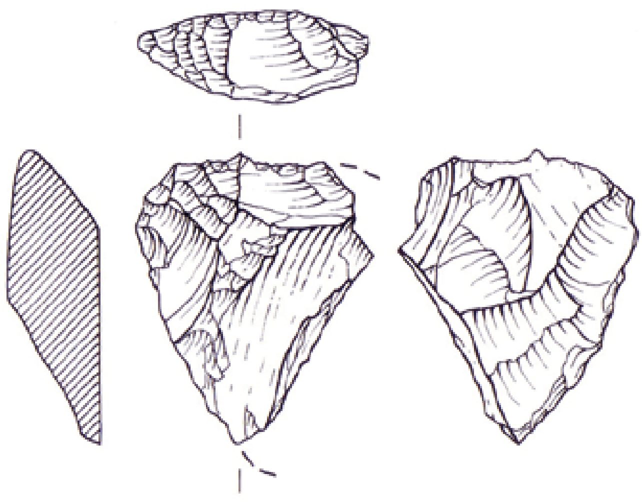
8.3 Modern sea bed activities such as trawling and scalloping and, more recently, aggregate dredging have resulted in the recovery of numerous archaeological artefacts as well as large collections of fossilised faunal remains which, as climatic and environmental indicators, can be used as proxies for direct archaeological evidence of the presence of humans in the prehistoric landscape.

8.4 The North Sea basin is particularly well-known in this respect, with Dutch fishermen reporting the recovery of thousands of animal bones in their nets from the Brown Banks (Louwe Kooijmans 1970–71; Flemming 2002) and numerous similar finds reported by the offshore aggregate industry (Wessex Archaeology 2007, 2008b). Other finds include a barbed bone or antler point of Mesolithic age found in a lump of peat snagged by a trawler in 1931 between the Leman and Ower banks (Gaffney *et al.* 2009; Louwe Kooijmans 1970–71), numerous lithic artefacts from the Solent (Wessex Archaeology 2004), the collection of handaxes and other stone artefacts recovered from Area 240 off Great Yarmouth (Wessex Archaeology 2009b) and the Neanderthal skull fragment reported from Dutch waters in the southern North Sea referred to above (Hublin *et al.* 2009).

8.5 Of particular relevance to this guidance is a worked Upper Palaeolithic flint found within a borehole core sample collected for oil prospecting near the Viking Bank between Shetland and Norway in 1981. The flint was covered by 28cm of recent silty sand, in a water depth of 143m, and based on available evidence may have been deposited when this area of the sea bed was last dry, between 10,000–18,000 years ago (Long *et al.* 1986). Although finds of archaeological material within core samples are rare, the discovery of this flint is evidence of a prehistoric human presence near the Viking Bank in the past, and illustrates the potential and importance of geotechnical samples to the study of submerged prehistoric archaeology.

8.6 These finds only hint at the wealth of prehistoric archaeological material that is likely to survive in submerged contexts around the UK and reflect not so much a deficiency in the archaeological record, as issues related to investigating that record in the marine environment, and thus a lack of baseline data. Furthermore, while they are indicative of the UK's submerged prehistoric archaeological potential, these finds are not particularly illuminating with respect to the wider palaeolandscape of the continental shelf.

Figure 5 The Viking Bank flint (drawing by Marion O'Neil, courtesy of the Trustees of the National Museums of Scotland)



Data Derived from Development Activities

8.7 With the increase in sea bed development and the pressures this brings to bear on the prehistoric archaeological record of the continental shelf, our knowledge of submerged landscapes needs to move beyond the speculative. An important area of research in the future will thus be to refine the chronology, extent and nature of palaeo-geographic change to and on the UK's continental shelf through the Quaternary period (Westley *et al*. 2004).

8.8 Sea bed mapping, using the well-established techniques listed by Bailey *et al.* (2010) (e.g. seismic profiling, sediment coring, radiocarbon dating or Optically Stimulated Luminescence (OSL) dating), will be fundamental to our ability to model these submerged prehistoric landscapes, identify areas with the greatest potential for human occupation and exploitation, and address the sorts of questions raised by Westley, *et al.* (2004). Bailey *et al.* (2010:7) suggest that new research should 'focus primarily on acquisition of new data from the continental shelf, as well as compiling and re-assessing existing archive datasets (e.g. collected by industry or for non-archaeological research purposes)'.

8.9 A recent example of archaeological palaeolandscape reconstruction, using data generated as a result of sea bed development, is the University of Birmingham's Doggerland project in the southern North Sea (Fitch *et al.* 2005; Gaffney *et al.* 2007, 2009). This has demonstrated how the 'reconstruction of the palaeolandscapes of the southern North Sea using 3D seismic data might be used to reveal the potential archaeological resource and develop a predictive methodology to assess the archaeological prospectivity of certain areas' (DECC 2009a: 533).

8.10 Submerged and buried palaeo-river systems on the continental shelf are important but poorly understood elements of submerged prehistoric archaeology. On the south coast of England, for example, fluvial terrace deposits associated with onshore valley systems contain some of the best records of early human occupation in the UK (Wymer 1999). In addition to being prime environmental niches for prehistoric human exploitation and occupation, palaeo-river channels were also foci of the topographic and taphonomic conditions described above, necessary for site preservation during sea level rise. As a result, it is likely that submerged palaeo-river channels and their associated sedimentary units in many offshore areas contain important palaeoenvironmental information, which can aid in reconstructing the environments that early humans inhabited. Furthermore, as magnets for prehistoric human activity it is highly likely that these systems contain archaeological sites or materials, which expand our knowledge of the early human occupation of the UK (Wessex Archaeology 2008a).

Research Agendas

8.11 The primary reason for archaeologically assessing offshore geotechnical data is based on the need to consider these data as part of the EIA process and gather sufficient data to make an informed decision about the potential impacts of development on the historic environment.

8.12 However, the results of EIA studies also increase knowledge and understanding of the UK's prehistoric past and the submerged former terrestrial landscapes of the continental shelf. Archaeological assessments of geotechnical data should, therefore, be informed by current research agendas, which map out the national and sectoral directions in research and identify research priorities.

8.13 The *UK Marine Science Strategy* (Defra 2010) is a 15-year strategic framework, prepared by the Marine Science Co-ordination Committee under the auspices of the Ministerial Marine Science Group, which aims to shape, support, co-ordinate and enable the delivery of world class marine science for the UK. The Strategy is linked to the Government's *High Level Marine Objectives* (see Appendix 1) and provides a high level direction to the development of marine science in the next decade and a half, particularly in the context of ensuring sustainable use of the sea and dealing with the effects of climate change. Although primarily focused on publicly-funded marine science, it takes account of relevant science funded by others, such as marine users and sea bed developers, and aims to improve the alignment of scientific effort – the 'collect once, use many times' approach – and improve communication about marine sciences.

8.14 Key research agendas related to submerged prehistory are identified in various research frameworks. For example, the *North Sea Prehistory Research and Management Framework* (Peeters *et al.* 2009) reflects the increasing international co-operation in submerged prehistoric research in north-western Europe and the increasing collaboration in addressing common problems of coastal and maritime zone management.

8.15 Elsewhere, current archaeological issues in the marine zone in England, including those related to submerged Palaeolithic and Mesolithic archaeological research, are being addressed in a *Maritime and Marine Historic Environment Research Framework* for England, commissioned by English Heritage and being collated by the University of Southampton.

8.16 The relevant sections of this draft framework identify the following key areas within the Palaeolithic and the Mesolithic for future submerged prehistoric archaeological research (Bailey *et al.* 2010; Bell *et al.* 2010):

- Investigating subsistence economies;
- Developing a better understanding of prehistoric population dispersal, (re-) colonisation and depopulation;
- Investigating the potential for and feasibility of prehistoric seafaring;
- Investigating the evidence for human adaptation to Arctic conditions;
- Investigating environmental productivity and seasonality in the context of the prehistory of north-western Europe;
- Developing a clearer picture of the role of the continental shelf in the Mid-Upper Palaeolithic transition between 45,000–30,000 years BP; and
- Investigating the socio-demographic impact of sea level and landscape change.

9 Geotechnical Survey and Site Investigation

9.1 The geology of the sea bed is a key consideration in the planning and construction of offshore renewable energy projects and an understanding of it is of vital importance in engineering and technical decisions for individual projects.

9.2 The sea bed is comprised of sedimentary deposits laid down under different environmental conditions and at different times in the past. Geotechnical investigations are concerned with the structure and strength of this material and how it will behave under the stresses of wind farm construction and operation. Archaeology is concerned with the palaeoenvironmental, climatic and chronological information contained within the different sediments.

9.3 The data generated by offshore renewable energy projects are usually collected for engineering purposes or to inform decisions about scheme layout, for example. However, their availability, the specifications according to which they are increasingly being acquired, and the development of the technical capacity within the archaeological community to process (and integrate) these datasets for archaeological and palaeoenvironmental purposes has generated a growing capability to use them to map submerged palaeo-landscapes and begin to interpret them archaeologically.

9.4 Information about sea bed geology is acquired through geotechnical ground investigations which seek to determine the physical, mechanical and chemical properties of subsurface sediments and assess any risks posed to the development by site conditions. In the case of offshore renewable energy, geotechnical investigations aid in determining foundation type and depth and in designing turbine and cable route layouts.

Figure 6 Geotechnical survey and coring vessel (courtesy of Fugro Geoconsulting)

9.5 Sediment coring is the method usually employed to acquire the detailed information about the sea bed geology that offshore development requires, and a number of standard coring techniques and types of equipment are widely employed by the geotechnical industry in the UK to recover undisturbed, stratigraphic sediment samples.

9.6 In order to provide guidance on how the archaeological assessment of geotechnical samples can best be integrated with geotechnical ground investigation and testing, the process, mechanics and logistics of offshore geotechnical survey and site investigation need to be explained.

Coring Techniques

9.7 There are two main coring techniques used offshore in the UK – boreholes and vibrocores. Both can produce sleeved sediment cores which are either tested offshore on the survey vessel or brought ashore for testing and analysis in geotechnical laboratories. In both borehole and vibrocoring the sleeves are mechanically driven into the sea bed and collect a representative column of the sediments through which they pass.

9.8 For archaeology, boreholes and vibrocores allow the direct observation of minimally disturbed stratigraphy (as long as the sediment is cohesive),

Figure 7a Vibrocorer set-up (courtesy of Emu Ltd)

the recovery of sediment samples for analysis, the ground truthing of geophysical data and, ultimately, the potential to map and model palaeolandscapes.

9.9 A third sediment testing method is Cone-Penetrometer Testing (CPT), in which an instrumented cone is pushed into the sediment to measure cone-tip resistance, friction against the cylindrical shaft and excess pore water pressure generated at penetration.

9.10 CPT does not produce a sediment sample useful to archaeology. Instead, it measures variations in sediment shear strength (the stiffness of the sediment being penetrated) and compressibility, and is able to discriminate boundaries or changes in sediment units, something that archaeological interpretation of geotechnical data is also keenly interested in. CPT results are thus of potential palaeoenvironmental and archaeological interest in the construction of large scale stratigraphic models (for example Bates *et al.* 2007), the production of cross-section data (Howie *et al.* 1998), and in the identification of palaeo-landsurfaces or buried structures, and can be used to complement the archaeological assessment of borehole and vibrocore samples. CPT is generally used in conjunction with borehole sampling, and the process produces a mixture of sleeved cores and unconsolidated bulk samples.

Figure 7b Vibrocorer deployment (courtesy of Emu Ltd)

Geotechnical Samples

9.11 In the context of offshore renewable energy these coring methods are applied differentially dependant on circumstance. Boreholes are able to provide deep penetration of the sea bed sediments and into bedrock, and are routinely used to recover cores and samples from depths of up to 50m below the sea bed at turbine locations to test ground conditions for foundations. Vibrocores have a maximum sea bed penetration of up to 8m, although they are normally 6m in length. Vibrocores tend to be used to assess ground conditions for the shallower elements of offshore renewable energy projects, such as inter-array and export cable routes.

9.12 Borehole samples are usually recovered in steel tubes. These sleeves are expensive and re-usable and core samples are generally extruded offshore in 90–100cm lengths. Each sample is logged (from the outside only and with minimal cleaning) and briefly recorded for sediment colour, grain size, inclusions, boundaries and fissures/discontinuities (see BS5930 and ASTM standards). The cores are then sub-sampled into ±25cm lengths of the most representative material (usually sediment boundaries), which are kept intact for laboratory testing. The remainder of the material is also retained, but as bagged and therefore ultimately disturbed samples. The logs of the samples created offshore are the basis for deciding what is tested when the core samples arrive at the lab.

9.13 For archaeological purposes the offshore extrusion and sub-sampling of borehole core samples presents some issues in that what is retained intact for geotechnical testing may not be of archaeological interest. Archaeologically important core material may, therefore, be retained only as bagged, and thus disturbed, samples.

9.14 As the name implies, vibrocoring employs a combination of the force of gravity, enhanced by energy supplied by a vibrating head to drive a plastic-lined steel core tube into the sea bed

Figure 8 Core logging aboard the survey vessel (courtesy of Fugro Geoconsulting)

sediment. Vibrocore samples are generally recovered in 6–8m tubes, which are cut into 1m lengths on recovery, for ease of storage and transport. Unlike borehole samples, vibrocores are generally not extruded offshore, but arrive at the laboratory, undisturbed, in the sleeves in which they were recovered. These sleeves are usually clear plastic, which allows the samples to be logged and roughly recorded on recovery. Black or opaque sleeves are available for use for samples required for certain tests, such as OSL dating.

9.15 In sea bed development contexts continuous boreholes are rare, except where they are drilled through rock. The geotechnical ground investigations are largely driven by engineering requirements and, therefore, the borehole core sections described above are usually interspersed with CPT samples taken to test end bearing/ resistance, friction and pore/fluid pressure in the soil. Core sampling and CPTs in adjacent boreholes are usually overlapped to obtain a full sediment record for the area from multiple boreholes.

Figure 10 Labelling of vibrocore samples (courtesy of Emu Ltd)

Figure 9 Vibrocore processing aboard survey vessel (courtesy of Fugro Geoconsulting)

9.16 Once recovered, geotechnical samples are subject to a range of laboratory tests, each designed to produce information about the properties of the sediments they contain. The majority of these tests are destructive, or at least alter the physical integrity of the core samples. This has implications for the archaeological assessment of these core samples, which tends to require intact and undisturbed samples, from which to extract information. There is thus a clear convergence of interest in core samples at this point, which has historically been difficult to resolve, but which the proposals made later in this guidance document attempt to resolve.

Figure 11 Offshore laboratory processing and testing of core samples (courtesy of Fugro Geoconsulting)

10 The Relationship between Archaeology, Geotechnics and Geophysics

10.1 The geotechnical techniques described above are invaluable to archaeologists and other geoscientists investigating areas of deeply stratified alluvium and the shallow marine zone, and their application has been discussed by a number of authors including Stafford (1995), Stein (1986, 1991), Barham and Bates (1994), Bates and Bates (2000) and Bates *et al.* (2000, 2007b).

10.2 Geotechnical methods are particularly useful for providing both direct and remote views of deeply buried stratigraphy, and are as applicable to offshore, submerged prehistoric archaeology as they are in the terrestrial archaeological environment. The data can be used to build sub-surface ground models and ultimately within a predictive modelling framework to predict areas of high archaeological potential (Stafford 1995; Deeben *et al.* 1997). The results have an important role to play as archaeological research tools and in informing heritage management strategies.

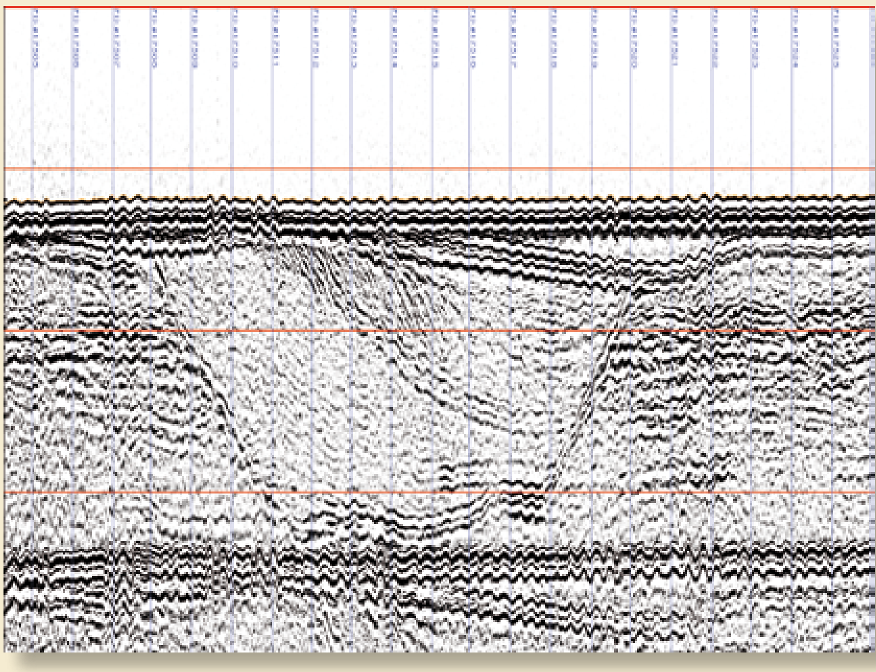
10.3 Geophysical data collected for offshore renewable energy developments are an important adjunct to geotechnical data in the investigation of submerged prehistory and palaeoenvironments and it is current best practice to review the results of archaeological geotechnical assessments against this geophysical data (see COWRIE 2007). The key geophysical datasets in submerged prehistoric research are:

- Sidescan sonar data, which provide photo-like acoustic images of the sea bed surface, giving an indication of outcropping geology, sea bed topography and changes in sediment type;
- Multibeam bathymetry data, which provide a quantitative depth model of the sea bed, giving an indication of changes in topography; and
- Seismic reflection data, which provide a sub-surface cross-section of the geology of the sea bed that can act as a framework on which to hang the actual sediment horizons identified in the geotechnical samples.

10.4 Geophysical data are particularly useful in the characterisation of wide areas of sea bed and sub-surface sediments. In the context of geotechnical assessments, these are used to establish whether sediments identified in cores are discontinuous lenses or extensive horizons and to highlight the presence of palaeochannels.

10.5 The archaeological assessment of geophysical data as part of the offshore renewable energy development process can provide an indication of the presence and/or extent and depth/thickness of buried sediments of archaeological interest in the development area. These results can then be ground truthed and investigated during the geotechnical assessment. The order in which the geophysical survey and geotechnical site investigations for any project take place is thus critical and this is discussed in more detail in relation to project planning below.

Figure 12 Palaeochannel in seismic data (courtesy of Emu Ltd)



11 Geotechnical Project Planning and Archaeology

11.1 Previous COWRIE guidance (COWRIE 2007:16–17) states that within EIA the historic environment is best dealt with through a process which is most effective when it is woven through the other strands that together make up the development process. The guidance states that a 'key finding, by archaeologists and developers alike, is that consideration of the historic environment should start early in the development process, and be maintained throughout'.

11.2 Project planning is therefore central to ensuring that the integration of archaeology with the geotechnical programme is achieved. As it relates to archaeology and geotechnical assessment, there are a number of key project planning elements that will ensure the meshing of archaeology with the geotechnical programme. These are discussed below and set out in a hypothetical timeline for a typical Round 3 project presented in Table 2, with project stages matched to archaeological activities and curatorial input.

Early Consultation

11.3 There needs to be consultation by the developer with the relevant heritage curator to agree the archaeological requirements of the project (JNAPC 2006; COWRIE 2007). To avoid problems experienced in the past, it is advisable to include archaeology in project planning at the earliest reasonable stage of the EIA process.

11.4 The curatorial response to consultation needs to be clear and unambiguous, and needs to ensure that meaningful archaeological results can be generated from development-led assessment, to inform the EIA.

Project Integration

11.5 Communication between the project's geotechnical and archaeological contractors to agree the brief for and integration of archaeology into the geotechnical programme, is also essential, as early in the planning process as possible.

11.6 In the past the tendency has been for archaeology to be introduced into the geotechnical programme after scopes of work have already been agreed, or cores have already been recovered, which allows little or no room for archaeological input and limits archaeological output. These issues can be resolved or avoided if archaeology is integrated into the project from the outset.

Input into Specifications

11.7 It is now common practice for there to be archaeological input into the proposed geotechnical scope of works, which is useful in ensuring the frontloading of archaeological integration into the geotechnical programme.

11.8 Discussion between geotechnical and archaeological contractors about their respective data needs will aid in the establishment of mutually beneficial working arrangements and timetables. This can facilitate the agreement needed on geotechnical methodologies and working practice that will ensure the optimal integration of archaeology with the geotechnical programme.

Cost Benefits

11.9 Ensuring that archaeological needs with regard to data collection and data assessment are understood and agreed early in the process will allow the geotechnical programme to be streamlined and the best use made of available staff, facilities and samples, which has potential cost benefits.

11.10 If, for example, archaeological cores are to be collected as part of the programme, projects should be planned to allow this coring to take place as part of the overall geotechnical site investigation programme.

11.11 The archaeological recording and sub-sampling of borehole samples as they are extruded on the survey vessel or in the laboratory can avoid the duplication of effort.

Survey Sequence

11.12 A further element which can influence the archaeological assessment of geotechnical data is the sequence in which geophysical and geotechnical surveys are carried out.

Table 2. Project Timeline and Archaeological Activities

Project Timeline	Environmental Investigations	Archaeological Activities	Curatorial Input
ZAP • Zonal geophysical survey • Geotechnical ground investigations • To inform the more targeted gathering of geophysical and geotechnical data to support EIA for project specific development proposals	• Consultation by developer with heritage curator to agree the archaeological requirements of the project • Consultation between project geotechnical and archaeological contractors to agree the brief for the archaeological aspects of the geotechnical programme • Zonal level geophysical survey • Geotechnical ground investigations for Metmast and to establish ground conditions across Zone	• Archaeological input into geotechnical scope of works (informed by archaeological assessment of ZAP geophysical data) • Archaeologist on board survey vessel and/or recovery of purposive archaeological core samples • Archaeological assessment of data, in combination with geophysical assessment	• Consulted by the developer with respect to broad archaeological issues and requirements related to the Zone
Choice of Sub-zone/ Site for development		Informed by results of Archaeological ZAP	
Site EIA • Geophysical survey • Geotechnical ground investigations	• Detailed geophysical survey • Detailed geotechnical ground investigations (usually a borehole/CPT at each proposed turbine location and vibrocores along cable routes)	• Archaeological input in to locations of geotechnical samples • Archaeologist on board survey vessel and/or recovery of purposive archaeological core samples • Assessment of geotechnical data (recording, sub-sampling and analysis and dating of core material)	• Consulted by the developer with respect to archaeological requirements of project • Consulted and comments on reports within framework of archaeological assessment of geotechnical data
Prepare Environmental Statement		Combined archaeological assessment of geophysical and geotechnical data informs Environmental Statement	
Submit Application			Statutory consultee on application
Licensing		• Production of landscape model • Publication of results of archaeological assessment, including landscape model • Deposition of project archive, including core material and paper and digital archive	• May propose licence conditions with respect to archaeological mitigation for project which may include requirements related to Geotechnics
Construction	Possible additional pre-construction geophysical and geotechnical investigations	Possible archaeological assessment of additional geotechnical data	Consulted with respect to archaeological mitigation proposals and results
Post-construction Monitoring	Post-construction collection of geotechnical data unlikely. Where this does occur, however, the curator will be consulted with respect to the need for archaeological assessment of these data		

11.13 It is common practice, although this is sometimes constrained by other factors, that geophysical surveys are undertaken in advance of the geotechnical site investigations (see Table 2). This is to allow the geophysical results to inform the geotechnical sampling programme, for engineering reasons.

11.14 The same sequence is preferable for archaeology, with the archaeological assessment of the geophysical data providing information that can inform the geotechnical assessment and in certain circumstances influence the positioning of geotechnical cores. The staggering of geophysical surveys and geotechnical site investigations is, therefore, central to optimising the results of the archaeological assessment of geotechnical data.

11.15 In this respect the renewable energy sector may draw lessons from the marine aggregate industry where there is already greater integration of data collection and consultation with specialists, such as archaeologists, in the planning of projects.

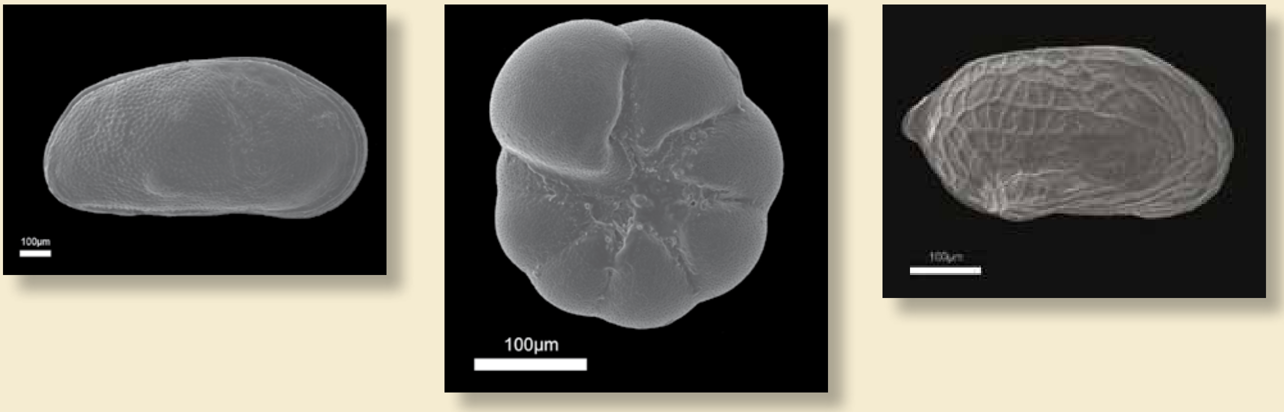
Archaeological Assessment Sequence

11.16 In the archaeological assessment of geotechnical data (see Section 13 below) the tendency has been to carry out each of these elements as a discrete work package. This has the potential benefit to the developer of creating a clear series of milestones at which the assessment process can stop, should further work not be deemed necessary by the archaeologist.

11.17 However, it is equally valid, and potentially reduces uncertainty for offshore renewable energy developers, to assume at the outset that all the elements are likely to be required, and to approach archaeological assessments as a package of sequential, but overlapping elements.

11.18 In both instances, a framework for regular reporting by the archaeologist to the client and the relevant archaeological curator will ensure that the assessment is undertaken to the appropriate level.

Figure 13 Ostracod *Cyprideis torosa*, lateral view (left), Foraminifera *Ammonia aberdoveyensis*, umbilical view (centre) and Ostracod *Cytherura gibba*, lateral view (right) (courtesy of Wessex Archaeology)



12 Archaeology and Conducting a Geotechnical Survey

12.1 The archaeological assessment of offshore geotechnical data and samples has been undertaken for a number of years, for a range of sea bed developments. As the heritage management response to offshore renewable energy by the relevant statutory consultees has developed, so the archaeological community, particularly archaeological consultancies, have developed a body of practice in development-led archaeological assessment of offshore geotechnical data.

12.2 The aim of the archaeological assessment of geotechnical data is to:

- Investigate the deposition sequence of sediments within the area represented by the cores to identify, as far as possible, the environments within which this deposition took place;
- Evaluate the potential for past human exploitation and occupation of these past environments;
- Produce an overview of the geological stratigraphy to provide an indication of the prehistoric archaeological potential for the area; and
- Comment on the archaeological importance of the identified deposits, within the context of the wider palaeoenvironmental history of the region and the UK.

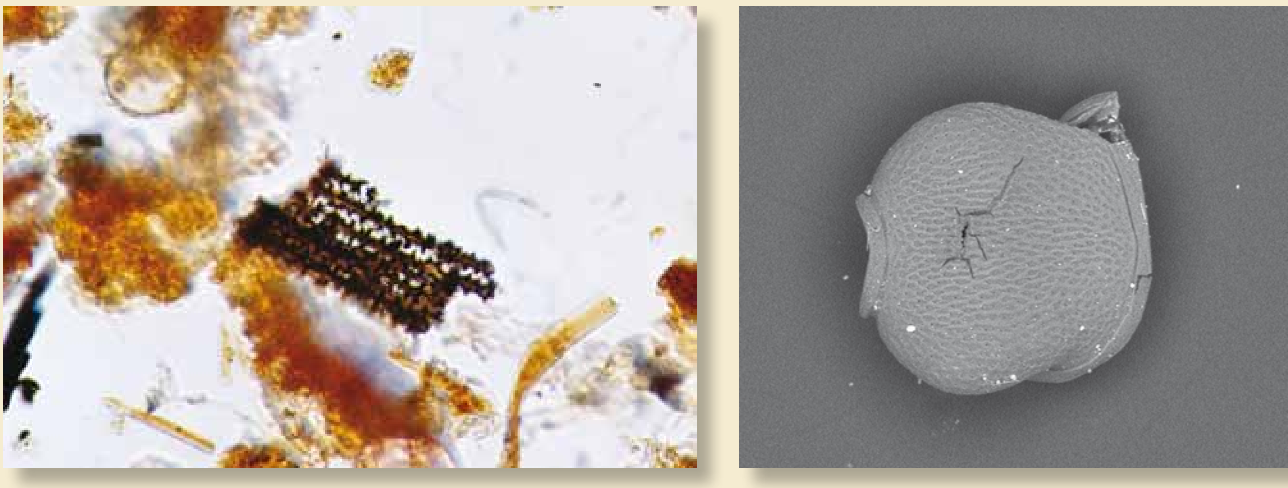
12.3 The stratigraphy of core samples is therefore, recorded and the cores sub-sampled for:

- Palaeoenvironmental and paleoclimatic indicators such as palynomorphs (pollen grains, spores and other microfossils), foraminifera, ostracods, mollusc shells, insects and plant remains which can be used to reconstruct the prehistoric environment;
- Organic materials such as peat, wood or charcoal which can be used to date sediment layers;
- Mammal macrofaunal remains which can be used to reconstruct landscape and habitat;
- Archaeological artefacts which provide direct evidence of a prehistoric human presence in the palaeolandscapes.

Integration with Geotechnical Programmes

12.4 Whilst the framework for archaeological integration into geotechnical programmes described above has been developed and is widely accepted within offshore renewable energy projects, in practice the integration of archaeological assessment into the geotechnical programme for offshore renewable energy has tended to be less than straightforward. The relationship between archaeological and

Figure 14 Magnified view of grass micro-charcoal (left) and part of the exoskeleton flower beetle *Anthicus gracilis* (courtesy of Headland Archaeology)



geotechnical assessments has developed as an *ad hoc* response to offshore renewable energy development in the last decade, and is flawed in several important areas.

Problem Areas

12.5 The first fundamental issue is that geotechnical samples recovered for offshore renewable energy projects are collected for non-archaeological purposes. They are acquired principally to inform the engineering and planning of projects and these requirements have thus had first call on the core samples. As a result archaeological access to core samples has generally been limited to those not required for geotechnical testing, which may or may not be those identified in the assessment of core logs as being of the greatest (or any) archaeological interest.

Figure 15 Archaeological recording of core sample
(courtesy of Wessex Archaeology)

12.6 Alternatively archaeologists and geotechnicians find themselves competing for the same, limited set of core samples, a situation made all the more difficult to resolve because both parties' assessment methodologies are destructive to the samples, but in mutually exclusive ways. The majority of tests carried out by geotechnicians on core samples are likely to preclude their later use for archaeological assessment. In the same manner, the archaeological recording of cores, which entails vertical splitting, renders such cores useless for geotechnical purposes.

12.7 A complicating factor in this has been the often late inclusion of archaeological assessment in the geotechnical programme. In many instances archaeological assessments have been commissioned long after geotechnical surveys and testing have been completed and, as a result, samples identified as of possible archaeological interest in the assessment of the core logs may no longer exist, having been destructively tested or discarded.

12.8 The other fundamental archaeological problem with the current situation is the fact that with very few exceptions the coring locations are planned around acquiring data for scheme development purposes, and are usually associated with turbine locations or the route of the export cable. The cores recovered can and do supply data that is useful in informing the archaeological EIA but because they do not, except possibly by chance, target areas of identified archaeological potential within the sea bed, means that the value of the archaeological assessment of geotechnical data for offshore renewable energy projects under these terms is not as high as it could be were core locations to reflect, to some degree, archaeological considerations.

12.9 This is not to say that archaeological assessment of geotechnical data already undertaken for offshore renewable energy projects is of no value. Within the existing framework these assessments have contributed constructively to the EIAs for specific renewable energy projects and also to expanding the submerged prehistoric archaeological knowledge base.

12.10 However, the experiences of archaeological and geotechnical contractors have demonstrated the problems with the current process and have raised questions about whether the current situation is tenable.

Potential Solutions

12.11 Given the importance of the UK's submerged prehistoric archaeological record as a fragile, non-renewable and finite receptor of national and international significance, requiring serious consideration in the context of offshore development and EIA the processes described above effectively filter the geotechnical data and its availability to archaeology and mean that the archaeological potential of these data are thus limited.

12.12 As the sole route for archaeological access to, and assessment of geotechnical data in support of the EIA process this is untenable and suggests that a paradigm shift is required in relation to archaeology and the development-led geotechnical programme. To achieve this, the following key points need to be accepted for offshore renewable energy projects:

- Geotechnical data acquired during offshore renewable energy developments is collected for archaeological as well as for engineering purposes. Archaeological input should thus be sought in the survey specifications and planning of core locations. This advice will be based on the archaeological assessment of geophysical data.
- Provision should be made during site investigation for an archaeologist or sedimentologist to participate in the site investigation and data collection.
  The presence of personnel on survey vessels with either archaeological or sedimentological training will enhance the archaeological knowledge gained from the engineering cores recovered and processed at sea (for example, through archaeological sampling of borehole core material that would otherwise not be available to archaeologists, except after geotechnical lab testing) and inform decisions about the placement of the archaeological cores.
- At least one purposive archaeological core should be collected per project. The location of this core will be determined by archaeological assessment of the geophysical data. This core will function as a control, against which the archaeological deposit model (see Section 15 below) is validated. Only by reserving a core for purely archaeological analysis will it be possible to get the full value out of archaeological assessment.

12.13 The availability of an archaeological core will streamline the relationship between geotechnical contractors and archaeologists and resolve the current competition for the same limited core resource. It will improve the quality of the geotechnical data available to archaeology and ensure better archaeological 'value' from assessments of geotechnical data because core locations can be targeted to areas of archaeological interest suggested by the assessment of geophysical data and because the full range of the resultant core material will be exclusively available for archaeological and other scientific research.

12.14 Furthermore it will result in the creation of an archive of cores or core samples (see below) of scientific value and interest not only to archaeologists which is important given the likelihood that the opportunities for geotechnical site investigations within the boundaries of offshore renewable energy projects during the operational lives of those projects are likely to be limited.

12.15 The proposals above do not imply a blanket requirement for collecting additional archaeological samples and it is acknowledged that there may be circumstances where this would be of little archaeological benefit. Instead they are aimed at establishing the principle, under the terms of EIA, that it is quite valid to collect primary data, such as geotechnical cores, for the purpose of archaeological analysis to inform the EIA.

12.16 This will place the historic environment and archaeology on an equal footing with ecological disciplines, such as those related to birds, marine mammals and benthic fauna, in terms of access to suitable primary data to inform the EIA process. It will meet any requirements for mitigation and, ultimately, enhance the basis for decision-making and management with respect to the marine historic environment. Co-operative working between disciplines should also foster a mutual consideration of how best to optimise analysis of cores obtained for environmental purposes.

12.17 The elements of the proposals above should thus provide a strong and clear basis on which the scheme-specific details of future archaeological assessment of geotechnical data – including the technical details of the palaeoenvironmental processing such as the level of detail required for logging and sampling cores, for example – can be agreed by offshore renewable energy developers, their archaeological consultants, and the curators.

13 Archaeological Assessment Phases

13.1 Archaeological assessments of geotechnical data generally consist of a number of stages of work (see Figure 16) and the following basic elements should be expected to form part of any archaeological assessment of geotechnical data:

Core Log Assessment

13.2 Often the first element in the archaeological assessment of geotechnical data, a review by a suitably trained archaeologist of the geotechnical core logs produced by the geotechnical contractor is undertaken to determine whether, from the sediment descriptions, there appear to be layers/sediments of archaeological interest.

13.3 Where there is an archaeological presence on site during ground investigations core logs may be reviewed later in the process to inform the archaeological assessment.

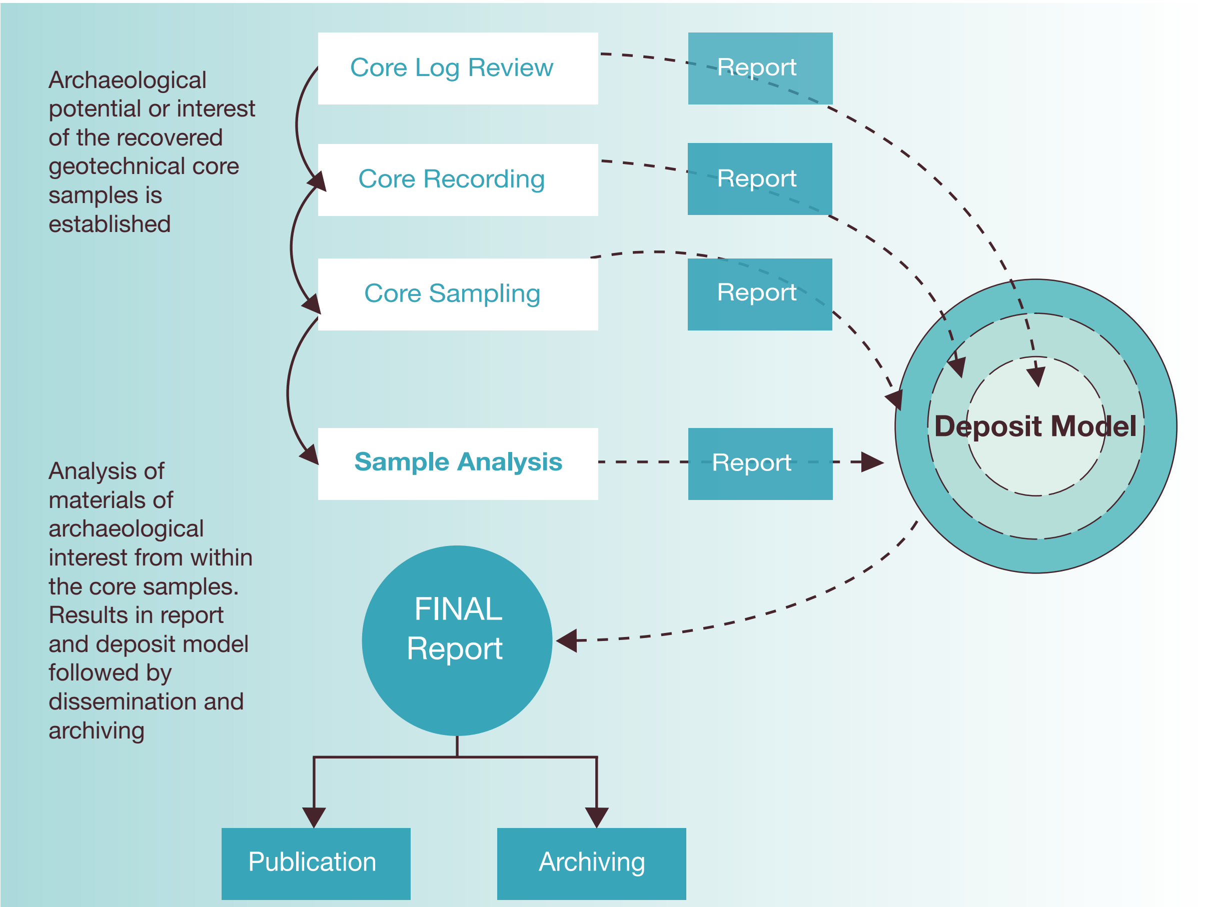
13.4 In general, the sort of material within core samples that is of particular interest to archaeologists are fine-grained sediments indicative of fluvial/estuarine conditions, and sediments containing organic remains such as peats or other plant material.

Core Recording

13.5 The archaeological recording of core samples may be a rapid exercise that takes place at the same time as the cores are initially logged by the geotechnical contractor, and/or the detailed recording of core samples of interest identified from the core log review described above or from the rapid recording exercise.

13.6 Core recording requires physical access by the archaeologist to the core samples, and will comprise detailed noting of such details as

Figure 16 Archaeological project phases



sediment colour, sediment type, sedimentary architecture, inclusions and other palaeo-environmental indicators and datable material.

13.7 Core recording serves as preservation by record of the individual core samples that will be subject to further archaeological assessment and analysis.

Archaeological Sampling

13.8 Where material of archaeological interest has been identified within core samples during core logging and recording, sub-samples are taken for archaeological laboratory assessment and analysis.

13.9 Archaeological sub-samples are generally between 1–5g in size, and should not affect the integrity of core samples. Sub-samples from sedimentary units of interest, such as alluvial silts and organic peats for pollen assessment are in the order of 1–2g in size, while those from organic units for radiocarbon dating are usually weigh about 5g.

If waterlogged plant macrofossils, insects, molluscs and macro-charcoal are encountered during the sampling process, larger archaeological sub-samples may be required. The acquisition of these sub-samples will be agreed through discussion with other core sample users.

Palaeoenvironmental Sample Assessment and Analysis

13.10 Archaeological sub-samples are subject to specialist assessment for and analysis of a variety of archaeological and palaeoenvironmental indicators of past terrestrial environments suitable for human exploitation. These include:

- Pollen
- Diatoms
- Ostracods and/or foraminifera
- Waterlogged plants
- Insects and molluscs
- Charcoal.

13.11 As appropriate, suitable material from samples will be sent for dating.

13.12 Assessment and analysis are undertaken to a level sufficient to enable the value of the palaeoenvironmental material surviving within the cores to be identified and described.

Reporting and Production of Deposit Model

13.13 The results of all the phases of the archaeological assessment undertaken will be used in the project assessment report to:

- Describe the sedimentary sequence and character of the deposits in the development area and create a relative chronology for them;
- Describe the palaeo-topography of the development area and past changes in its environment;
- Describe the archaeological potential of the deposits within the development area; and
- Inform the development of a deposit or landscape model of the development area.

13.14 A model of the deposits of archaeological interest in the development area will be produced from the results of the preceding assessment phases. The complexity of and detail within this model will depend on the results of the assessment. Deposit models are discussed in more detail in Section 15 below.

13.15 The submission of an assessment report to the curator and production of a deposit model will occur at whatever stage of the project no further archaeological assessment is warranted. The report produced and the detail in the deposit model will reflect the level of the work conducted.

13.16 On completion of the project, a final copy of the report and any other deliverables, such as a deposit model, should be lodged with English Heritage's National Monuments Record. In addition, an OASIS form (see below) should be completed for the project.

Publication or Dissemination of Results

13.17 The results of the archaeological analysis are integrated with the findings of other areas of the archaeological assessment and submitted for publication. Further discussion of data dissemination and archiving can be found in Section 16 below.

Creation of Project Archive

13.18 The data generated by an archaeological project must be deposited and held, for future use, in an appropriate archive which is accessible and in the public domain.

13.19 An archaeological archive will comprise all research, any physical objects such as artefacts or samples, any analyses and models, and the resultant reports generated by a project.

13.20 Until an archive has been created an archaeological project cannot be said to have been completed. Information about archaeological archives and data repositories is provided in Section 16.

Summary

13.21 Although these elements of the archaeological assessment of geotechnical data are inherently sequential, it should be clear from the above that there are elements that may be conducted together to streamline the process. There is also scope for individual offshore renewable energy projects to tailor their approach to the archaeological assessment of geotechnical data, based on the project, the developer, the archaeological consultant and the curator, the key proviso always being archaeological access to suitable primary geotechnical data.

14 Archaeological Mitigation

14.1 Through the EIA process, the archaeological assessment of geotechnical data forms part of the mitigation of the effects of offshore renewable energy development on the submerged prehistoric environment.

14.2 Mitigation can be defined as a process for eliminating or reducing to an acceptable level the adverse effects of an action: in this case the effects of offshore renewable energy projects on prehistoric archaeological sites, materials and palaeolandscapes.

14.3 Mitigation measures are thus design and operational modifications or other measures implemented to avoid, minimise or offset the adverse effects and enhance the positive effects of a development during each stage of its life. Mitigation can take place at any stage of the life of a project, including pre-submission or pre-consent, and will often be based on the measures proposed in the project EIA (COWRIE 2007).

14.4 Consent for offshore renewable energy projects is likely to be subject to conditions, many of which will give effect to mitigation measures proposed in the project EIA, and are aimed at ensuring that these measures are implemented.

14.5 Although the details of archaeological mitigation measures will differ from project to project, offshore renewable energy developers should expect that historic environment curators will require the agreement with them of a plan or framework for archaeological mitigation.

Marine Archaeological Project Plans

14.6 The likely extent of archaeological mitigation measures for any offshore renewable energy project will be encapsulated in the archaeological project plan. This plan is the overall programme of archaeological work for that project, which should be agreed during initial project planning and scoping between by the developer, the curator and the archaeological contractor.

14.7 The project plan should set out the range and phases of archaeological work likely to be expected across the life of the project. This will include both EIA-related work, which is generally pre-consent, and post-consent archaeological work, which is often more mitigatory in nature.

14.8 Of relevance to this guidance, the project plan should include provision for archaeological input into the geotechnical survey specifications to ensure that the archaeological outputs from the assessment of geotechnical data can be achieved.

Written Schemes of Investigation (WSI)

14.9 The detail of specific archaeological mitigation measures in the project plan is set out in what have become known as Written Schemes of Investigation (WSI).

14.10 A WSI is a formal and detailed archaeological method statement, which through its implementation will ensure the mitigation of development effects on all elements of the archaeological record.

14.11 Previous guidance (COWRIE 2007) describes a WSI as a document which can be used to explain when and how mitigation measures recommended in the Environmental Statement are to be implemented for any project. A WSI can thus be expected to:

- Set out the respective responsibilities of the developer and contractors, including the archaeological contractor with respect to the implementation of archaeological mitigation measures;
- Ensure archaeological input into and assessment of any future geophysical and geotechnical investigations undertaken for the project;
- Set in place any archaeological exclusion zones within which no development activities may take place;
- Propose practical measures and methodologies for mitigating effects on any archaeological material encountered during the construction and operation of the project; and
- Establish the reporting, publication, conservation and archiving requirements for the archaeological works undertaken in the course of the project.

14.12 From the list above it is clear that most WSIs have tended to be produced as part of the project

EIA, or post-consent as a consent condition. It is important to be aware, however, that WSIs are increasingly being produced early in offshore renewable energy projects for pre-consent works. This is particularly the case for geotechnical investigations which require archaeological input from early in the project.

14.13 With respect to the archaeological assessment of geotechnical data for any project, the overall plan of archaeological works and the specific archaeological methodologies set out in WSIs will together support the interpretation of geotechnical data, both pre- and post-consent.

Mitigation Outputs

14.14 The proposals above for, *inter alia*, an archaeological presence on geotechnical site investigations and the collection in future of dedicated cores for archaeological assessment should ensure that particularly during the pre-consent stage of the project the established mitigation framework can be effectively implemented.

14.15 This will produce both more reliable and relevant EIA input and greater archaeological value to inform the existing knowledge base and management of the archaeological record.

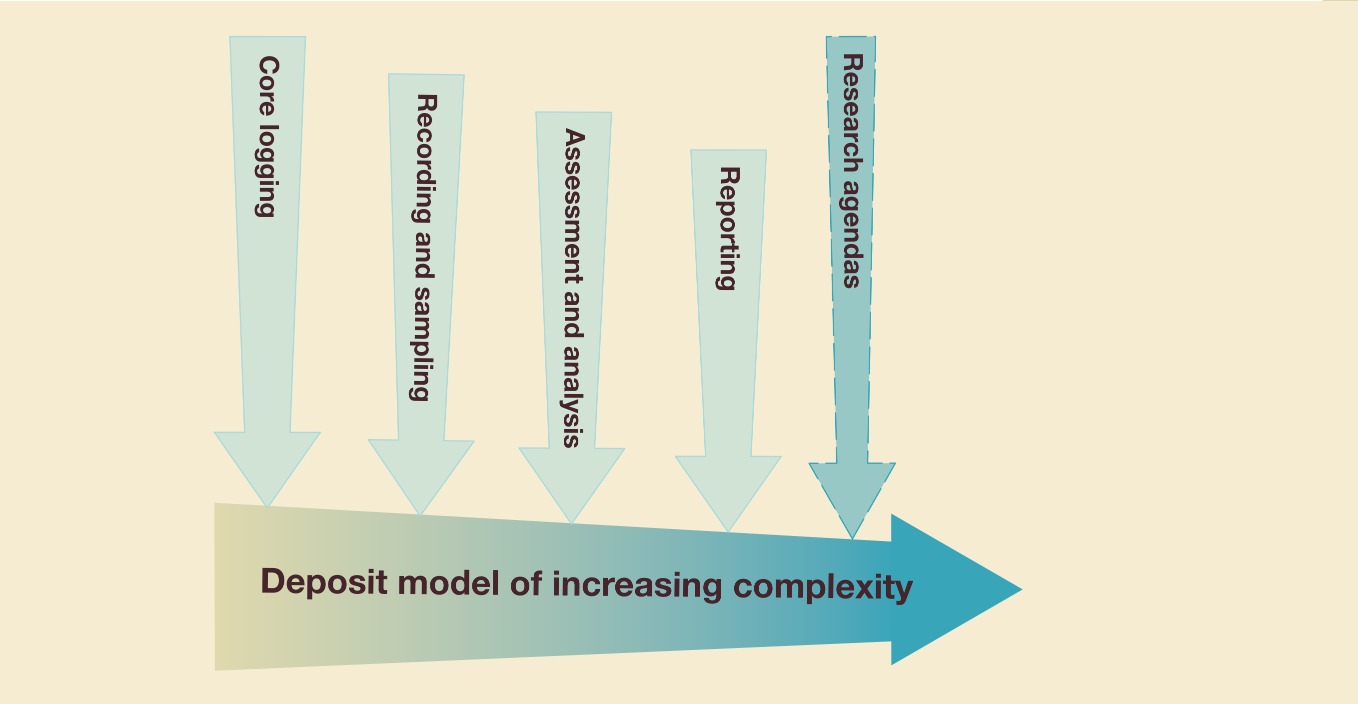
14.16 As outlined above, the principal outputs of the archaeological assessment of geotechnical data are the project reports and a deposit model. These can be produced at any stage of the archaeological process. Only the complexity and level of detail will vary.

14.17 Project reports will generally be illustrated technical reports, each building on the results of the preceding report/s. They will:

- Detail the data assessed;
- Outline the archaeological assessment methodology employed for each phase of work;
- Present the results, in combination with those from earlier phases of work as relevant; and
- Make recommendations as to the need for and nature of any further work.

14.18 The deposit model is described in more detail in the following section.

Figure 17 Archaeological assessment outputs



15 Modelling Prehistoric Landscapes

15.1 A model is a simplified representation of any system, complemented by a hypotheses required to describe the system. Sedimentary deposit modelling for archaeology is undertaken in the context of offshore development to provide a reconstruction of the subsurface stratigraphy in areas of Holocene and Pleistocene sequences where archaeology may be buried (Bates 1998, 2000, 2003). The assumption is that sediments deposited as part of fluvial or terrestrial processes in the past are indicative of landscapes, which may have been exploited or occupied by early humans.

15.2 Archaeological deposit modelling therefore endeavours to extract from the available geotechnical and geophysical data the extent, character and nature of the geomorphological record. To achieve this, the deposit model maps sedimentary layers of archaeological interest to define how far the landscape represented by the deposit extends and, supported by information from the archaeological assessment, when it was deposited and what sort of environment it represented.

15.3 Deposit modelling focuses on the ancient sedimentary environments and their contemporary ecological conditions and allows the extrapolation and interpolation of deposits across and beyond the area where data have been collected.

15.4 An important caveat, however, is that landscapes discernable in geophysical and geotechnical data are not strictly fossilised 'Mesolithic' or 'Upper Palaeolithic' landscapes for example, but are instead palimpsests of numerous topographic features combined from stacked time periods.

15.5 The modelling process involves the integration of information generated by the different elements of the archaeological assessment described in Section 13 above and the results of geophysical data interpretation. These elements are introduced into the deposit model as the information becomes available throughout the archaeological assessment process, and each new element builds, strengthens and refines the model and the archaeological hypothesis underpinning it.

15.6 Because of the difficulty of identifying archaeological sites and materials in the submerged, marine environment, within the context of the offshore EIA process landscape becomes a primary focus of prehistoric archaeological investigation. Describing landscapes within which archaeological sites or material may reside, through modelling, is a means for assessing the potential for early humans to have lived in the landscape.

Deposit Models and the Development Process

15.7 The questions relevant to offshore renewable energy developments that can be addressed by archaeological deposit modelling include:

- What sediments are within the development area?
- What is their archaeological interest?
- What sedimentary deposits of archaeological interest will be directly impacted by the development?
- What is the significance of the impact?

15.8 These questions assume that we understand the extents and types of deposits that survive offshore. This not the case, even though our knowledge of the preservation of archaeological material and deposits of archaeological interest surviving on or within the sea bed is rapidly expanding.

15.9 Therefore, we require a greater understanding of submerged prehistoric archaeology offshore. This understanding will be partly enhanced by the volume of geotechnical investigation undertaken as part of the Round 3 programme.

15.10 There is thus a feedback loop between increasing knowledge and the understanding of the effects of development on submerged prehistoric archaeology: the effective assessment of development impacts on submerged prehistory is enhanced as more studies are undertaken.

15.11 These questions are also central to decisions regarding the amount of archaeological assessment work undertaken on cores, guided by discussions with the curators.

15.12 The sediment record itself, represented by geotechnical cores, therefore, becomes of archaeological interest. Within the offshore renewable energy geotechnical assessment process sediments that contain palaeo-environmental and dating information take on more importance as they represent a finite resource, with the potential to contextualise other information though palaeogeographic reconstruction.

15.13 Deposit models are thus an archaeological or cultural heritage management tool within the EIA and offshore development process and will inform project design (such as turbine location and cable routing).

15.14 Modelling allows offshore zones or areas to be ranked in terms of their potential to contain deposits of archaeological interest or archaeological sites and to be delineated across an area of sea bed. In the context of offshore renewable energy development, deposit models can act as a measurement of risk, both to the development process and the submerged prehistoric record. Beyond the EIA process the model and its constituent data also have the potential to inform current and future archaeological research.

Modelling Outputs

15.15 The primary goal of an archaeological deposit model for an offshore renewable energy development is to inform the assessment of impact. To achieve that it is essential that the models produced are rigorous and of a publishable standard, and can provide a clear understanding of the relationship between the vertical stratigraphy and horizontal extent of sediments within a development area.

15.16 An archaeological deposit model must therefore illuminate the character and nature of buried sediments and deposits, their vertical extents, their relationships across the area being studied, and their individual levels of archaeological interest.

15.17 Data in a deposit model can be presented in many different ways and the possible modelling outputs will depend to the density of data, the range and type/s of data available and the resolution of these data. Together these factors will determine the level of accuracy and the degree to which the model approximates reality. They will also influence the scale of the model because as scale increases, so data density, resolution and the availability of multiple datasets becomes increasingly critical to the level to which the model is accurate and approximates reality.

15.18 It is thus important to always remember that a deposit model such as those described below is only as good as the data it contains. It is possible to refine and improve models – to reduce the extent to which there will be anything unforeseen in the sedimentary modelling – through the addition or inclusion of new data from subsequent surveys or phases of investigation.

15.19 Whilst it is possible to reduce the unforeseen in a deposit model almost completely there will nevertheless always be the possibility of sediments and deposits that are ‘unforeseeable’ (Baynes 2010) and which cannot be accounted for in the deposit model.

15.20 It should also never be forgotten that a deposit model is a representation or approximation of reality, based on an interpolation of data from various sources, be that core samples or geophysical data, or both.

15.21 There is a range of possible types of deposit models, of which the following are described and illustrated below:

- Two-dimensional section diagrams;
- Interpreted geophysical data overlain with core logs; and
- Three-dimensional models comprising one or more dataset.

Section Diagrams

15.22 A simple deposit model, using geotechnical data, can be represented by linking the sediment layers identified in cores in a two-dimensional section diagram as illustrated in Figure 18.

15.23 This figure shows an interpolated relationship between deposits of the same type from adjacent cores across space. The section diagram is accompanied by a plan view of the core distribution, and together these two elements represent a basic model of the deposits within the area in question.

15.24 Simple two-dimensional models such as this are best suited to either small areas, areas where there are clear, corresponding sediment layers, or areas where there is a high core density.

15.25 A variation on the model described above is presented in Figure 19 where core data are superimposed on geological data generated from geophysical survey (2D).

15.26 In a model such as this there is no need to create hypothetical interpolations between core samples because stratigraphic mapping of seabed sediments is available from the interpretation of seismic data, for instance. The benefit of this form of deposit model lies in the fact that the superimposition of geotechnical and geophysical data can be used to ground truth the results of geophysical interpretation.

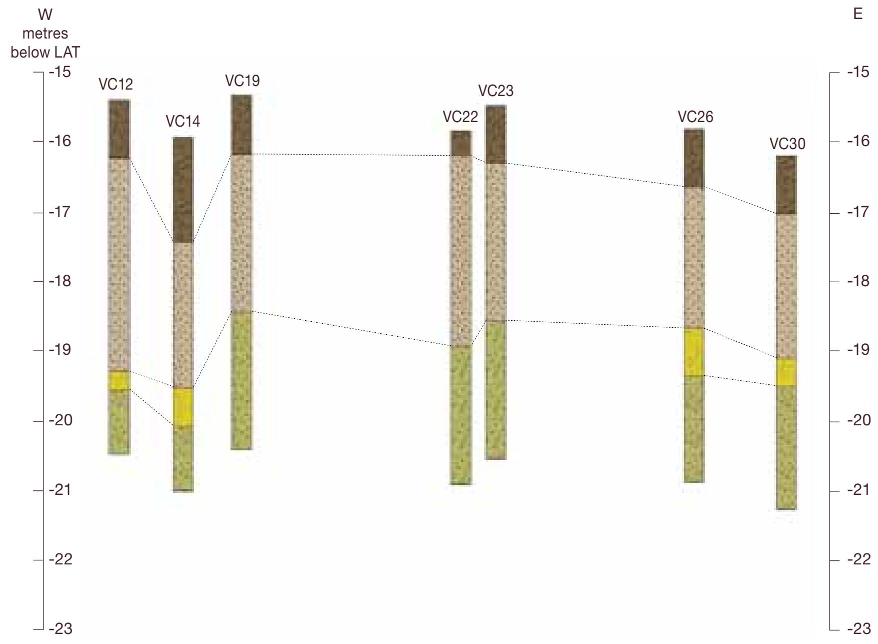


Figure 18 Example of a section diagram showing the relationship between a number of adjacent cores

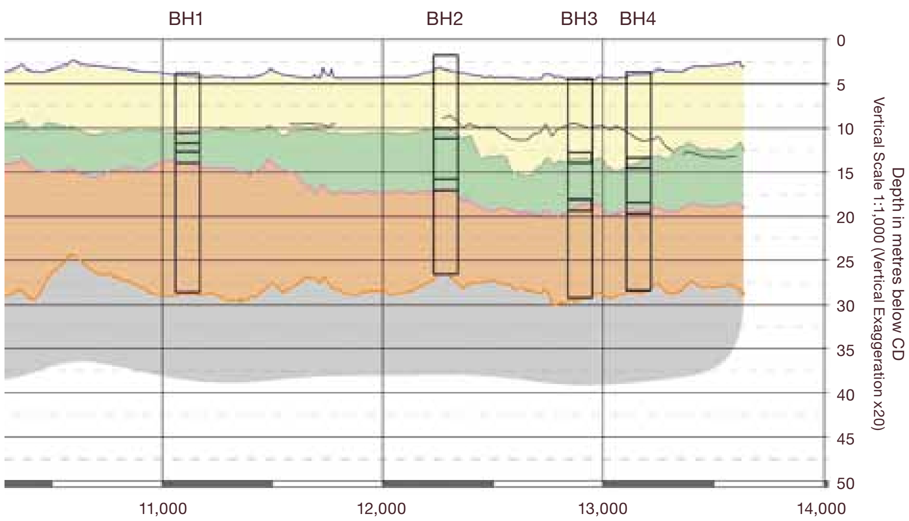


Figure 19 Section diagram showing core information superimposed on geological data

Three-dimensional Models

15.27 A more complex, three-dimensional deposit model such as that shown in Figures 20a and 20b can be produced with the aid of one of a number of geological and geotechnical modelling software packages on the market.

15.28 From core log data (Figure 20a) the software can interpolate the relationships between the sedimentary horizons within boreholes across a wide area. This can be used to create a diagram or framework of surfaces representing parts of landscapes from different depositional events that can be viewed and manipulated in three dimensions (Figure 20b).

15.29 The addition of other datasets such as multibeam bathymetry and shallow seismic profiles (see Figure 17) to the base core data can

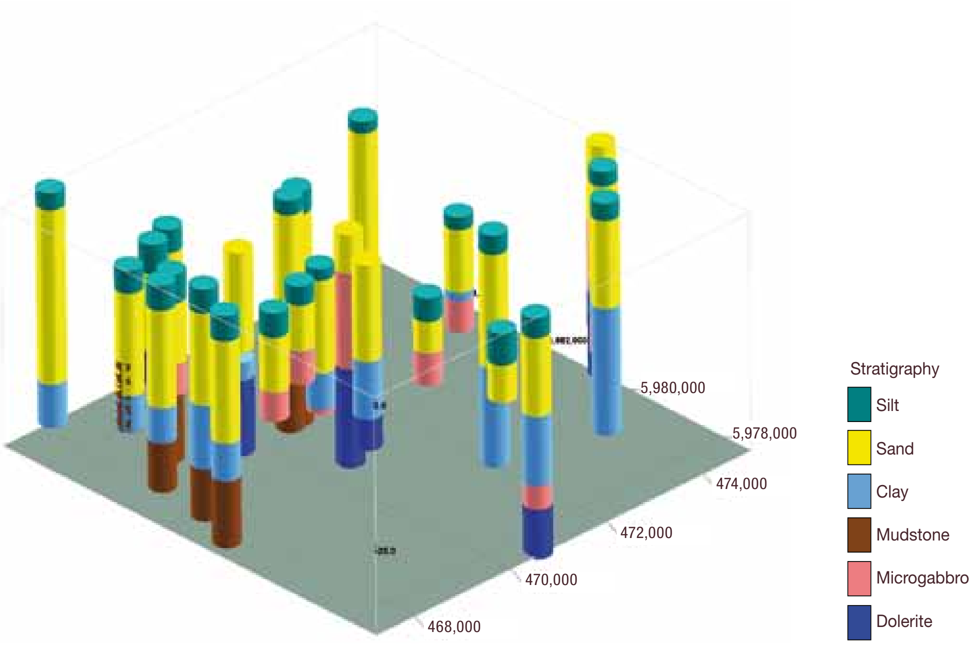


Figure 20a
3D model showing core distribution and content

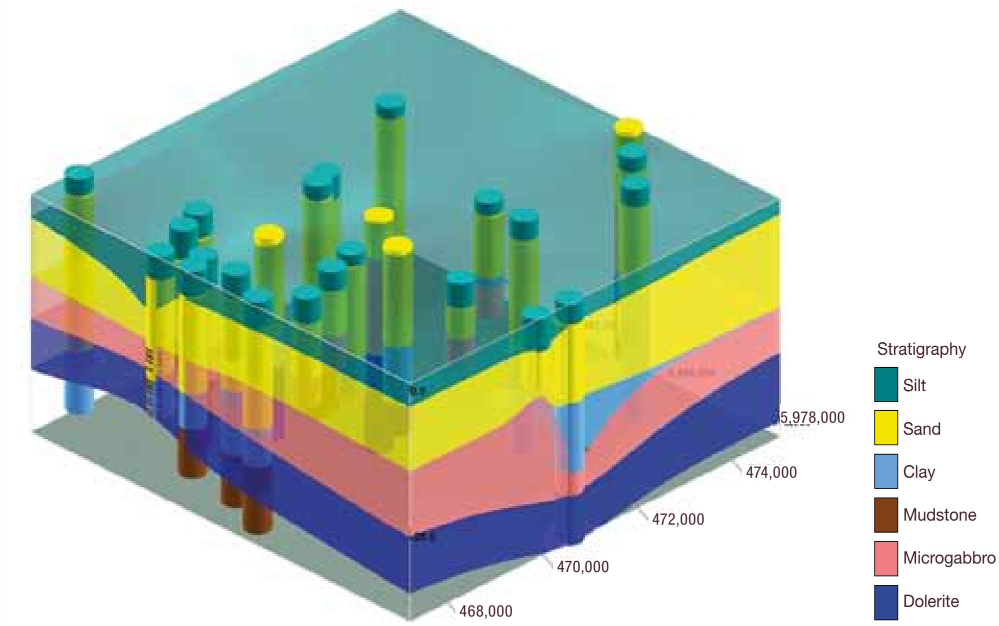


Figure 20b
3D model showing interpolation of sediment layers between individual core locations

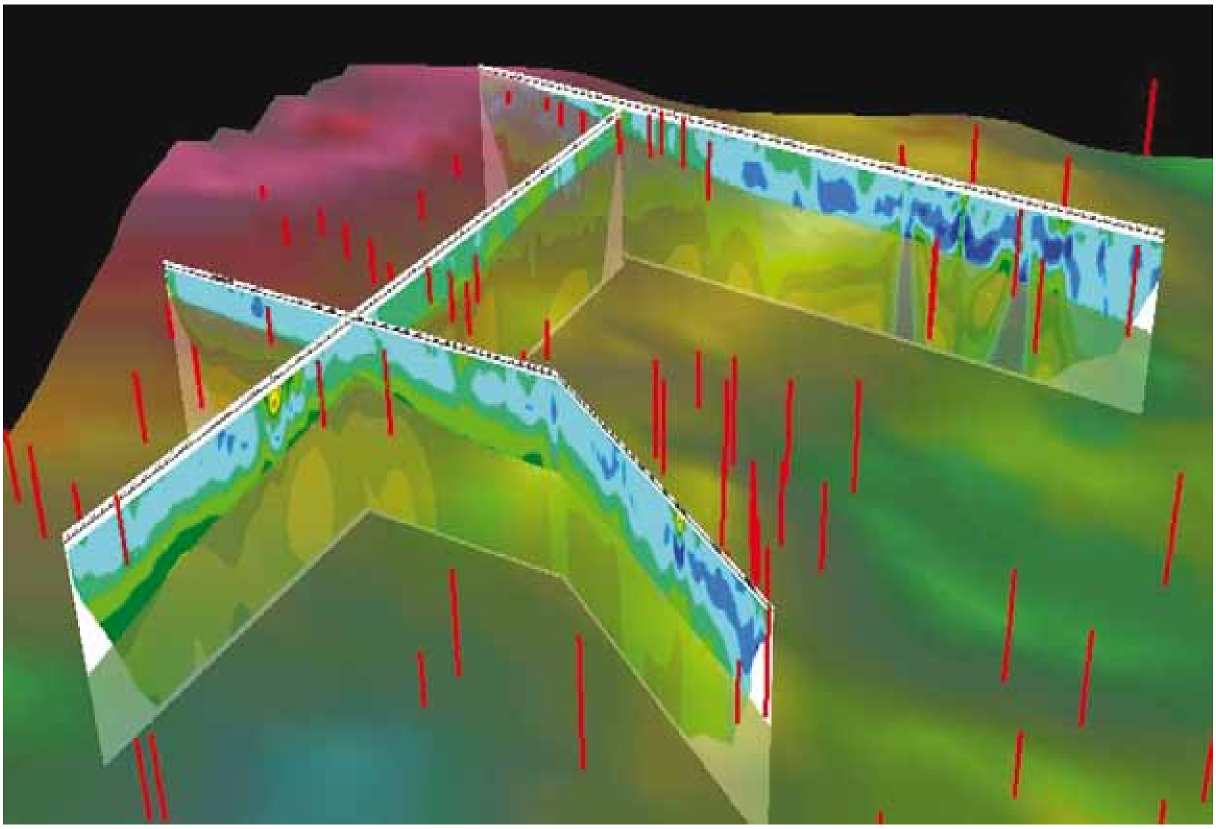
improve the resolution of the interpolation of relationships between sedimentary layers.

15.30 Three-dimensional modelling can facilitate the mapping across space of individual sedimentary horizons, either within the model itself or as individual horizontal slices through the model for use in GIS analysis, for example. This means that the extent of sedimentary horizons of archaeological interest identified within individual geotechnical cores can be better understood across an offshore development area.

15.31 This is an important archaeological consideration within the offshore development process in that it allows archaeologists to predict with a greater degree of certainty if and where sediments of archaeological interest may be impacted by development and, by extension, what the effects of the development are likely to be on the submerged prehistoric archaeological record. In addition, archaeological deposit models are a means of mitigating that impact by preserving knowledge of the seabed conditions.

15.32 Digital and other archaeological modelling outputs must be archived appropriately at all stages of a project to ensure that the model is able to contribute to the assessment of impacts both on a site-specific and cumulative basis.

Figure 21 3D sediment model combining seismic and geotechnical data (courtesy of Martin Bates)



16 Data Dissemination and Archiving

16.1 The archaeological record is finite and non-renewable and any intervention, including archaeological investigation, is inherently destructive because of its impact on the physical integrity of any site, deposit or materials.

16.2 Responsibility for ensuring that this disturbance does not result in the irretrievable loss of archaeological information falls to the person or persons responsible for the intervention, and is achieved through preservation by record – i.e. by ensuring that archaeological work and its results are fully documented, to the extent that allows the virtual recreation of the archaeological site, post-intervention.

16.3 The same principles are applicable in the archaeological assessment of offshore geotechnical data, which may be viewed as a limited evaluation excavation and indicate the presence of deposits and features worthy of further investigation. Just as is the case when excavating a site, archaeologists will generally have a single opportunity to record and sample core material and preserve it by record. The creation of a full and accessible archaeological archive for any such geotechnical assessment is therefore essential.

16.4 It also requires as a distinct activity that archaeological results are published and disseminated to ensure maximum exposure within both the archaeological and academic communities and the wider public, thereby enhancing the value of the archaeological work and results.

16.5 The proper archiving of data arising from development-led archaeological activities so as to allow their future accessibility for re-use, and the dissemination of the results and their publication in both the professional and public spheres is thus a responsibility carried by renewable energy developers through their archaeological contractors.

16.6 Most archaeological contractors in the UK are bound by the professional standards of the Institute for Archaeologists (IfA) (http://www.archaeologists.net/codes/ifa) which provide a means of validating their work and ensuring the maintenance of the highest possible standards and good practice across the profession.

Publication and Dissemination

16.7 Archaeologists have a moral and ethical obligation to publish or disseminate the results of their work: an obligation codified in the principles of the IfA's *Code of Conduct* (1985, revised April 2010).

16.8 The appropriate level of publication and dissemination will depend on the results of the project and the advice of the heritage curator. The advice to applicants offered by the National Policy Statement for Renewable Energy in this regard is that historic environment assessments should 'include the identification of any beneficial effects on the historic marine environment, for example through improved access or the contribution to new knowledge that arises from investigation' (DECC 2009c:43). This echoes the principle set out in the *High Level Maritime Objectives* (Defra 2009a) that new scientific research and data collection should inform and develop our understanding of the marine environment.

16.9 There is a broad range of potential publication outlets available to archaeologists, including international, national and local academic journals, and local interest magazines. Increasingly there is also the option of online publications or platforms such as Scribd (http://www.scribd.com/), which are particularly useful for the publication of grey literature, which is defined by the Grey Literature Network Service (Luxembourg, 1997 – Expanded in New York, 2004) as 'information produced on all levels of government, academics, business and industry in electronic and print formats not controlled by commercial publishing i.e. where publishing is not the primary activity of the producing body'. Examples of grey literature include technical reports from government agencies or scientific research groups, working papers from research groups or committees, and client reports produced as part of development-led archaeological projects.

16.10 Publication of development-led archaeological work carries with it certain sensitivities that the archaeologist undertaking the work must respect, particularly the requirements of the client or commissioning body over confidentiality. The professional obligation to make the results of archaeological work available to the wider community within a reasonable time must be borne in mind in commissioning offshore renewable energy archaeological assessments, and an agreement on this should ideally be reached between the developer and the archaeological contractor before work commences. For practical reasons this is also important as the publication and dissemination of archaeological results has financial implications for the developer that need to be factored into the archaeological budget.

Archaeological Archives and Data Repositories

Archaeological Archives

16.11 An archaeological archive is defined by the IfA *Standard and Guidance for the Creation, Compilation, Transfer and deposition of Archaeological Archives* as 'all parts of the archaeological record, including the finds, samples, and digital records as well as the written, drawn and photographic documentation' (IfA 2009:2).

16.12 The IfA describes an archaeological archive as 'a researchable resource' generated by archaeological investigation which is 'the key to understanding any published interpretations of the archaeological results' (IfA 2009:2) and must be accessible and kept for future reference.

16.13 Thus, all archaeological projects that generate data of any sort must result in an archive which will be accessible and in the public domain. All archaeologists are, therefore, responsible for ensuring that as part of any project the necessary archive is created. Until a full and accessible archive has been created an archaeological project cannot be said to have been completed.

16.14 An archaeological archive will comprise all research, any physical objects such as artefacts or samples, any analyses and models, and the resultant reports generated by any project.

16.15 As the only record of a site or material available for future reference the importance of the archive in the archaeological process and the contribution it makes to our common heritage can, thus, not be over-stated (Archaeological Archives Forum 2009).

16.16 Curation of these records of archaeological work and archaeological finds and samples as an archive in a recognised repository will ensure the survival of archaeological evidence and records for future use, which may include the 're-analysis of data, the re-interpretation of evidence, renewed understanding of events, objects or structures, re-publication of findings or the presentation of evidence or materials in a public context' (IfA 2009:2).

16.17 Where the archaeological work has utilised other data sources, such as geophysical or geotechnical data, the archive must include clear signposts to where these data are archived and how they may be accessed in the future.

16.18 Modern archaeological projects are increasingly generating or using large amounts of digital information and there is an increasing awareness that these vulnerable data are as much a part of the project archive as the artefacts and paper records that have traditionally found their way into museum stores. Acknowledging this, the Arts and Humanities Data Service (AHDS) have produced *Digital Archives from Excavation and Fieldwork: Guide to Good Practice* to provide guidance on how best to create digital archaeological records and deposit them in a digital archive facility for future use (see Archaeological Data Service below). This guidance can be found at: http://ads.ahds.ac.uk/project/goodguides/excavation/

Data Repositories

Archaeological Repositories

16.19 Although there is currently a critical lack of long-term, accessible and secure homes for maritime archaeological archives (HWTMA 2009a-c) the following national, publicly accessible archaeological data repositories exist in the UK, all of which accept data, if not artefacts, generated by archaeological work in the marine environment:

- The National Monuments Record has a selective archiving policy and accessions archaeological site archives of national importance. Other archives are retained at local and county level (see http://www.english-heritage.org.uk/server/show/nav.19915);

- National Monuments Record of Wales at the Royal Commission on the Ancient and Historic Monuments in Wales collects and curates archaeological records and archives (paper, photographic and electronic) within the terms of the NMRW Collecting Policy. NMRW is the national repository for records of the archaeological, architectural and historic environment in Wales. In effect this means that all archaeological archives, without associated finds, created by any organizations or individuals, are accepted by RCAHMW for the NMRW (see http://www.rcahmw.gov.uk/HI/ENG/Search+Records/The+NMRW/);
- National Monuments Record of Scotland at the Royal Commission on the Ancient and Historic Monuments in Scotland is the designated archive for all fieldwork records, including digital data, generated during archaeological fieldwork in Scotland. RCAHMS requires that archaeologists working in the marine environment submit an OASIS form on completion of any archaeological assessment, including the assessment of geotechnical data. Project records should define the spatial extent of the overall project, archaeological activities undertaken within the project and the location and extent of any sites recorded. In addition, in Scotland, a summary interim report should be published in Discovery and Excavation in Scotland which provides an annual digest of fieldwork in Scotland and its maritime waters (see http://www.rcahms.gov.uk/index.html);
- Built Heritage Division, Department of the Environment in Northern Ireland is the statutory depository for all records from fieldwork within the province (see http://www.ni-environment.gov.uk/).

16.20 The specific procedures and requirements of each with regard to depositing data are available directly from the repository concerned.

The COWRIE Data Management System

16.21 In terms of The Crown Estate lease agreements offshore renewable and wave and tidal energy developers have an obligation to supply The Crown Estate with data generated by their projects.

16.22 COWRIE Ltd has created an infrastructure to handle these data – the COWRIE Data Management System (see http://data.offshorewind.co.uk/), which is the repository for all environmental records and information generated by offshore renewable energy projects. The system was created to ensure the long term accessibility and archiving of data and information for the renewables industry and the wider marine community.

16.23 Through a Data Catalogue accessible to any registered user, the system provides access to metadata and, through search criteria and interactive maps allows users to find, view records and download data and information resources.

16.24 The data required for submission to the system include primary observations and metadata related to both the geotechnical and cultural heritage investigations, modelling and monitoring on the site. In respect of geotechnical data these include the results and data collected that relate to site investigations and core analysis, but excludes the core samples themselves, for which there is no requirement to archive by The Crown Estate.

16.25 The administration and maintenance of the system will in future pass to The Crown Estate.
Marine Environmental Data and Information Network (MEDIN)

16.26 The Marine Environmental Data and Information Network (http://www.oceannet.org/) was established in 2008 and is an open partnership of UK organisations, funded by a group of sponsors drawn from government departments, research institutions and private companies. The network has as its raison d'être improving access to and management of UK marine environmental data, and aims to achieve this through the development of a co-ordinated national marine data management framework.

16.27 MEDIN will not hold or curate data itself, but is establishing instead a network of marine Data Archiving Centres (DACs) which will provide secure, long-term storage for marine data, including archaeological data from marine contexts. The network will act as the portal through which to search for, upload, or retrieve data from the DACs. There are currently four MEDIN-accredited DACs:

- British Geological Survey (BGS) for sea bed and sub-sea bed geology, geophysical data;
- British Oceanography Data Centre (BODC) for water column oceanographic data;
- Data Archive for Seabed Species and Habitats (DASSH) for benthic flora, fauna and habitat data; and
- UK Hydrographic Office (UKHO) for bathymetry data.

16.28 Geotechnical data can, at present, be deposited through MEDIN with the BGS (see below).

16.29 The intention for the future is that the network of DACs will expand to include some or all of the national archaeological data repositories referred to above, and discussions are taking place with the heritage organisations to consider how MEDIN can best work with these repositories.

16.30 The archaeological assessment of geotechnical data uses the latter to produce derived information, including the computer models described above, which should be recorded and archived through the national heritage archives and any possible future archaeological thematic DAC.

16.31 One of the results of the MEDIN initiative, therefore, is to establish a clear process for the deposition of archaeological results of geotechnical assessments so they will be archived in the most suitable location and be subsequently accessible through MEDIN and the heritage gateways.

Geotechnical Data Archiving

16.32 The archiving of geotechnical data and core samples generated by offshore renewable energy projects needs to be considered in tandem with the arrangements made for the archaeological data archives, whether the samples were collected as part of the geotechnical ground investigations or for archaeological purposes.

16.33 Although offshore renewable and wave and tidal energy developers have an obligation to lodge data relating to individual projects with COWRIE this excludes the physical cores themselves, for which there is no requirement by The Crown Estate to archive.

16.34 In practice, however, renewable energy project-generated geotechnical core samples are retained and archived for a period of some years, usually the duration of the project construction phase, and usually by the geotechnical contractor. The data are retained for reference purposes, in case geotechnical questions not answered during the initial assessment arise during scheme construction. Thereafter the data are generally discarded.

16.35 These data and core samples may be of wider scientific interest, however, and are a potentially valuable research resource because of the extensive nature of the offshore renewable energy sector's geotechnical ground investigations. Although some of the data collected during Rounds 1 and 2 may already have been discarded, consideration should be given a) to preserving what remains in a suitable storage facility for future study, and b) to ensuring that suitable data generated during the course of Round 3 and other future offshore renewable developments (both those collected for engineering and archaeological purposes) are appropriately archived, especially as future scientific investigations within the footprints of offshore renewable energy installations is likely to be severely limited.

16.36 The network of DACs is currently being developed through MEDIN, and there will be greater clarity in time as regards suitable geotechnical data archives. The only DAC currently suitable for geotechnical archiving is the BGS which will, in broad terms, accept geotechnical cores and related data (such as core logs and geophysical data), provided they are accompanied by suitable metadata, and preferably not restricted by any form of commercial embargo on use. There is precedent for the deposition with the BGS of data with a limited period of embargo, and such arrangements will need to be agreed on a case by case basis with the BGS. Further information should be sought from the BGS (http://www.bgs.ac.uk/).

Archaeological Data Service

16.37 The Archaeology Data Service (ADS) (http://ads.ahds.ac.uk/), based at the University of York, collects, catalogues, manages, preserves, and encourages re-use of digital resources created by archaeologists. The ADS normally holds only digital information and is not equipped to adequately archive paper-based resources.

16.38 The ADS will provide an archival home for any digital archaeological data of interest to UK archaeologists and undertakes to migrate these data through changing technology to ensure that their intellectual content will be available in the future. Data deposited with the ADS is usually required to be available for public distribution and use.

16.39 The guidance with respect to standards for digital archaeological archives is available from the ADS.

OASIS

16.40 The Online Access to the Index of archaeological investigations Project (OASIS) (http://www.oasis.ac.uk/index.cfm) is an inter-organizational initiative in England and Scotland to provide an online index of the huge quantity of grey literature generated as a result of the development-led archaeological projects. Data producers, such as archaeological contractors, are encouraged to log project reports on the OASIS data capture form from whence the data will be filtered down to local and national data managers, such as Sites and Monuments Records and NMRs. The information is also passed on to the ADS for inclusion in its online catalogue ArchSearch (http://ads.ahds.ac.uk/catalogue/).

16.41 Until relatively recently the OASIS system could not accept records generated offshore, but the system has now been updated and archaeologists working in the marine environment should, as a matter of good practice, submit an OASIS form on completion of any archaeological assessment, including the assessment of geotechnical data.

Emu Ltd
January 2011

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Useful Websites

Archaeology Data Service (ADS) – http://ads.ahds.ac.uk/

British Geological Survey (BGS) – http://www.bgs.ac.uk/

COWRIE Data Management System – http://data.offshorewind.co.uk/

Infrastructure Planning Commission (IPC) – http://infrastructure.independent.gov.uk/

Institute for Archaeologists – http://www.archaeologists.net/modules/tinycontent/index.php?id=1

Marine Management Organisation (MMO) – http://www.marinemanagement.org.uk/works/energy/index.htm

Marine Environmental Data and Information Network (MEDIN) – http://www.oceannet.org/

Planning Policy Statements

England: PPS5: *Planning for the Historic Environment* and PPS22: *Renewable Energy* – http://www.communities.gov.uk/planningandbuilding/planning/planningpolicyguidance/planningpolicystatements/planningpolicystatements/

Northern Ireland: PPS 6: *Planning, Archaeology and The Built Heritage* and Draft PPS 18: *Renewable Energy* – http://www.planningni.gov.uk/index/policy/policy_publications/planning_statements.htm

Scotland: *Scottish Planning Policy* – http://www.scotland.gov.uk/Publications/2010/02/03132605/8

Wales: *Ministerial Interim Planning Policy Statement (MIPPS) 01/2005 – Planning for Renewable Energy* – http://wales.gov.uk/topics/planning/policy/mipps/?lang=en

Acronyms and Glossary

Archaeology – the study of past human societies, through the recovery and analysis of the material remains and environmental data they have left behind.

Archaeological Potential – a term used to describe the likelihood that buried archaeology survives within a geographical area or sedimentary deposit.

Archaeological Project Plan – the programme of archaeological work undertaken for any offshore renewable energy project the aim of which is to identify, assess, reduce and/or mitigate the effects of the development on the archaeological record.

COWRIE – Collaborative Offshore Wind Research into the Environment

Devensian – the most recent glacial period or ice age, the Devensian started *c.* 115,000 years ago, and ended with the onset of the Holocene (see below). The Devensian ice sheets reached their maximum extent roughly 26–21,000 years ago, and covered much of the UK, in places up to a mile thick.

EIA – Environmental Impact Assessment is a process which identifies the environmental effects (both negative and positive) of development proposals, in accordance with the requirements of the EU Environmental Impact Assessment Directive (as transposed into UK law through various sets of EIA regulations).

Fluvial – the term used to refer to the processes associated with rivers and streams and the deposits and landforms they create. When the rivers or streams are associated with glaciers, ice sheets or ice caps, the terms glaciofluvial or fluvioglacial are used.

Geoarchaeology – a multi-disciplinary approach which uses the techniques of geology, geography and other Earth sciences to study the natural physical processes that affect archaeological sites.

Geotechnical programme – includes the collection of samples and data during site investigation and the post-fieldwork laboratory testing of samples.

Historical Environment – all aspects of the environment resulting from the interaction between people and places through time, including all surviving physical remains of past human activity, whether visible, buried or submerged.

Historic Landscape Characterisation (HLC) – is a process that involves the examination and mapping of the landscapes that surround us as a means for understanding their historical development and managing their future development.

Holocene – a geological epoch which began *c.*11,000 years ago and which continues to the present. The Holocene began at the end of the last (Devensian) glaciation and has been a relatively warm, interglacial period.

HWTMA – Hampshire and Wight Trust for Maritime Archaeology.

Interpolate – to make assumptions of activity between two or more known parts using the data from those points.

Ipswichian – the interglacial period preceding the Devensian glaciation, and dating to between *c.*130–115,000 years ago.

Lacustrine – means of, or relating to, a lake.

Marine transgression – occurs when an influx of the sea covers areas of previously exposed land. It is usually associated with rises in sea level during interglacial periods.

MEDIN – Marine Environmental Data and Information Network.

Mesolithic – the period of prehistoric human technological development following the Palaeolithic and characterised by the use of microlithic stone tools. The Mesolithic (or Middle Stone Age) in the UK began *c.*11,500 years ago at about the same time as the start of the Holocene, and ended *c.*5,500 years ago with the introduction of Neolithic farming.

Neanderthal – an extinct branch of the human family dating to the period *c.*130–30,000 years ago, and named for the site at which fossilized remains were first found in the Neander Valley in Germany.

OSL – Optically Stimulated Luminescence is an optical dating method used mainly on geological sediments to determine how long ago buried minerals (typically quartz and feldspar) were last exposed to sunlight.

Palaeoenvironment – an ancient or past environment.

Palaeolithic – the earliest of the three divisions of the Stone Age, dating from the first use of stone tools *c.*2.6 million years ago to the appearance of microlith-using hunter-gatherers at the start of the Mesolithic (*c.*11,500 years ago).

Palynology – the study of organic walled microfossils such as pollens, spores and algae.

Pleistocene – the epoch covering the period *c.*2.5 million to 11,000 years ago.

Prehistoric – the period of human history pre-dating written records, the archaeological study of which is based on material remains or artefacts that survive into the present.

Quaternary – the most recent of the three periods of the Cenozioc Era, the Quaternary spans the last roughly 2.5 million years, and includes the Pleistocene and Holocene Epochs.

Radiocarbon dating (^{14}C) – a radiometric dating method based on measuring the observed abundance of a naturally occurring radioactive carbon isotope (^{14}C) and its decay products in a sample, using known decay rates.

Regional Environmental Assessment (REA) – is a high-level environmental assessment designed to brief regulators and stakeholders on the potential regional cumulative and in-combination impacts of future development plans.

Renewable Energy Zone – an area of the sea, beyond the United Kingdom's territorial sea, which may be exploited for energy production. The Renewable Energy Zone is co-extensive with the area within which the UK already exercises jurisdiction with respect to marine environmental matters, in accordance with Part XII of the United Nations Convention on the Law of the Sea.

SEA – Strategic Environmental Assessment is a formal system of incorporating environmental considerations into development policies, plans and programmes, and extends the aims and principles of EIA beyond the project level.

Subaerial – a geological term meaning 'under the air' used to describe events or structures that are located at the Earth's surface.

Taphonomy – the process by which plant and animal remains accumulate and differentially preserve within archaeological sites.

Tranchet axe – a stone tool made by removing a flake parallel to the final intended cutting edge of the tool, which creates a single straight edge as wide as the tool itself. Tools of this type are found in some Lower Palaeolithic Acheulean assemblages, and appear again during the Mesolithic.

WSI – Written Scheme of Investigation. The formal methodological framework resulting from the EIA process for ensuring the post-consent mitigation of development effects on all elements of the archaeological record.

ZAP – Zone Appraisal and Planning is a framework intended to rationalise and balance the commercial aim of maximising development capacity aspirations with the practicalities of delivery.

Appendix 1
UK Marine Planning Regime

A1.1 The Marine and Coastal Access Act 2009 (HMSO 2009) has introduced a new marine planning system for UK waters, which has the sustainable development of the UK marine area at its heart. The Act requires that all public authorities taking decisions that may affect the marine area of the UK do so in accordance with a UK Marine Policy Statement.

High Level Maritime Objectives

A1.2 To inform the development of the Marine Policy Statement (MPS) the UK Government, Northern Ireland Executive and the Welsh Assembly Government published *Our Seas – A Shared Resource: High Level Maritime Objectives* (Defra 2009a). This document sets out a number of high level marine objectives which are articulated in the context of the following sustainable development principles:

- Achieving a sustainable marine economy;
- Ensuring a strong, healthy and just society;
- Living within environmental limits;
- Promoting good governance; and
- Using sound science responsibly.

A1.3 The following high level objectives have a bearing on marine cultural heritage:

- The marine environment and its resources are used to maximise sustainable activity, prosperity and opportunities for all, now and in the future;
- People appreciate the diversity of the marine environment, its seascape, its natural and cultural heritage and its resources and act responsibly;
- The use of the marine environment is spatially planned where appropriate and based on an ecosystems approach which takes account of climate change and recognises the protection and management needs of marine cultural heritage according to its significance;
- Our understanding of the marine environment continues to develop through new scientific and socio-economic research and data collection;
- Sound evidence and monitoring underpins effective marine management and policy development; and
- The precautionary principle is applied consistently in accordance with UK Government and Devolved Administrations' sustainable development policy.

A1.4 The Scottish Government has included these objectives in Sustainable Seas for All – A consultation on Scotland's first marine bill, published in 2008 (Scottish Government 2008).

Policy Statements

Marine Policy Statement

A1.5 The planned Marine Policy Statement will be the first part of new systems of marine planning being introduced around the UK under the terms of Section 44 of the Marine and Coastal Access Act 2009. It will provide the high level policy context within which Marine Plans will be developed, and set the direction for marine licensing and other relevant authorisation systems.

A1.6 In England the Marine and Coastal Access Act 2009 and the MPS will be implemented within the Territorial Sea (12 nautical miles) and adjacent offshore areas within UK Controlled Waters (up to 200nm) by the Marine Management Organisation (MMO) which is responsible for licensing offshore renewable projects that generate up to 100 megawatts of electricity.

A1.7 The draft MPS identifies the historic environment of coastal and offshore zones, which it defines as including sites or landscapes of archaeological interest, as representing a unique aspect of the UK's cultural heritage. It states, therefore, 'that opportunities should be taken to contribute to our knowledge and understanding of our past by capturing evidence from the historic environment and making this publicly available, particularly if a heritage asset is to be lost' (Defra 2009b: 16).

A1.8 This echoes the High Level Maritime Objectives which state that based on its significance, the protection and management needs of marine cultural heritage must be recognised in order to achieve sustainable development of the marine environment (Defra 2009a).

A1.9 Section 54(4) of the Marine and Coastal Access Act 2009 informs the preparation, implementation and review of Marine Plans by setting out the duties of a marine plan authority (as defined in Section 50) to keep relevant matters affecting the exercise of its functions under review. This includes the historic and archaeological characteristics of any marine plan area.
National Policy Statements

A1.10 The Marine Policy Statement and marine planning system will work alongside revised planning systems in the UK.

A1.11 With respect to the historic environment and offshore renewable energy, the draft National Policy Statement for Renewable Energy (EN-3) acknowledges that archaeological sites and materials exist offshore and within the inter-tidal zone, and include prehistoric remains 'which existed prior to sea water rises' (DECC 2009c: 43).

A1.12 The NPS offers the following advice to applicants with regard to the historic environment, which is relevant to this guidance:

- The relevant statutory consultees should be consulted at an early stage of the project development with regard to the historic environment requirements;
- Historic environment assessments should be undertaken in accordance with best practice and take into account any geotechnical or geophysical surveys that have been undertaken to aid the wind farm design;
- Assessment should include the identification of any beneficial effects on the historic marine environment, for example through improved access or the contribution to new knowledge that arises from investigation.

A1.13 The NPS set the policy framework for the Infrastructure Planning Commission (IPC), which was responsible for determining consents for nationally significant infrastructure projects (NSIPs), such as offshore renewable energy projects in excess of 100 megawatts. The IPC is due to be replaced by the Major Infrastructure Planning Unit within the Planning Inspectorate.

Appendix 2
Other Relevant Guidance

A2.1 In terms of practical guidance on geotechnical site investigations and process, the Offshore Site Investigation and Geotechnics Committee of the Society for Underwater Technology has published *Guidance Notes on Geotechnical Investigations for Marine Pipelines* (SUT 2004). While the focus of this document, which is currently undergoing a process of review, is the geotechnical requirements of marine pipeline design and installation, it nevertheless provides broad guidance on acceptable good practice in the collection of geotechnical data. The document can be found online at: http://sig.sut.org.uk/pdf/PipelineGeotechInvestigGuidNotes%20Rev0300.pdf.

A2.2 Specific guidance on the application of earth sciences to archaeology has already been produced by English Heritage (2004) in a document entitled *Geoarchaeology: Using earth sciences to understand the archaeological record*. This document presents important information on palaeo-site formation processes, the deposits they produce, and also includes a useful section on the main methods used in geoarchaeology and the types of information they produce, which can also be applied to archaeological assessments of offshore geotechnical data. This guidance document does not extend to the submerged offshore environment, however, and this is where the current document aims to provide expanded information and guidance to optimise offshore geotechnical investigations.

This document was produced by Emu Ltd on behalf of COWRIE Ltd, with the aim of providing guidance and best practice options in relation to the integration of archaeological assessment into offshore renewable energy project-led geotechnical investigations.

The inclusion of archaeological considerations at all levels of the geotechnical planning, acquisition and assessment process is vital to ensure not only the cost-effective and efficient use of resources for the developer, but also to ensure optimum data collection strategies and the best use of the acquired data for archaeology. This document will provide practical guidance to developers and their geotechnical and archaeological contractors on how best to achieve this.

This guidance will thus assist offshore renewable energy developers, geotechnical, archaeological and environmental consultancies and contractors, industry regulators and other authorities, and national and local historic environment curators in managing the marine historic environment during the Environmental Impact Assessment process.

ISBN 978-0-9565843-6-6

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