AGGREGATE LEVY SUSTAINABILITY FUND
MARINE AGGREGATE AND THE HISTORIC ENVIRONMENT

SEABED PREHISTORY: GAUGING THE EFFECTS OF MARINE AGGREGATE DREDGING

ROUND 2
FINAL REPORT

VOLUME I: INTRODUCTION

Prepared for:

English Heritage
1 Waterhouse Square
138-142 Holborn
London
EC1N 2ST

Prepared by:

Wessex Archaeology
Portway House
Old Sarum Park
Salisbury
SP4 6EB

Ref. 57422.31

February 2008

SEABED PREHISTORY R2

FINAL REPORT

VOLUME I: INTRODUCTION

Ref. 57422.31

Summary

This report is Volume I of the Final Report of the project entitled 'Seabed Prehistory: Gauging the Effects of Marine Aggregate Dredging'. This project was funded by Round 1 and Round 2 of the Aggregate Levy Sustainability Fund (ALSF) distributed by the Department for the Environment, Food and Rural Affairs (Defra).

The funding of the project was administered on behalf of Defra by English Heritage (EH) and the Mineral Industries Research Organisation (MIRO), each funding different phases of the project. Each phase consisted of an independent stand-alone project with over-arching aims and objectives.

The Final Report consists of a synthesis of the reports from each phase. This report comprises eight volumes of which Volume I (this volume) presents an introduction to the project, Volumes II to VII focus on the individual study areas and Volume VIII presents the results and conclusions of the project overall.

The project arose directly from WA's experience of assessing the effects of marine aggregate dredging on the historic environment. It sought to address strategic gaps identified in the course of preparing Environmental Statements (ES) for marine aggregate extraction licence applications. Specifically, it addressed methodologies for assessing and evaluating the potential prehistoric archaeological resource of a given area of seabed.

The initial phase of the project started in Round 1 of the ALSF. The Round 1 'Seabed Prehistory' project was undertaken between 2003 and 2004 as part of the Sustainable Land Won and Marine Dredged Aggregate Minerals Programme (SAMP) administered by Mineral Industries Research Organisation (MIRO) on behalf of the former Office of the Deputy Prime Minister (ODPM), now Department for Communities and Local Government (DCLG).

The project was extended in Round 2 in order to assess the application of the Round 1 methodologies to aggregate dredging zones with different geoarchaeological characteristics.

This volume is the introductory volume and it aims to provide an overview of the project from its inception and execution through to the project conclusions.

This report provides the overall project background, its objectives and the adopted methodological approach. Furthermore, it outlines the baseline environment, including the

general marine geoarchaeology and its relation to submerged prehistoric landscapes, problems of palaeogeographic reconstructions, the wider archaeological context of prehistoric northern Europe populations and submerged prehistoric archaeology as well as settlement patterns and ethnographic analogues. The preservation of artefacts and the nature of archaeological deposits are discussed before final conclusions are drawn.

The project objectives were:

- To better understand the extent and character of prehistoric seabed deposits;
- To develop new methodologies for assessing and evaluating prehistoric seabed deposits in the course of licence applications;
- To guide industry, regulators and public towards better understanding, conservation and appreciation of prehistoric seabed deposits implicated by marine aggregate dredging.

In order to achieve this, a series of survey methodologies were undertaken which comprised:

- Bathymetric surveys which established water depth and geomorphology of the current seabed;
- Sidescan sonar surveys which allowed the seafloor sediments to be interpreted;
- Shallow seismic surveys which allowed the sub-surface geology to be interpreted and individual geophysical horizons to be digitally modelled;
- A judgement-led vibrocoring programme based on the results of the geophysical data, allowing calibration in terms of the sediment stratigraphy, of the identified geophysical horizons and providing samples for environmental analysis and dating;
- The integration of the information from the geophysical survey and the vibrocore programme enabling the reconstruction of palaeolandsurfaces;
- A systematic grab sampling programme over part of the study area to assess the probability of locating artefacts and exposed fine-grained sediments within the surface layers of the seabed.

Both the project methodology and conclusions have been presented to a wider audience through a series of conference and seminar papers and posters. These have included industry and regulators as well as the research community.

An assessment of the baseline environment sets out the problems surrounding the submerged prehistoric archaeology, including questions of the identification and assessment of timescales, cyclical climate change and its consequences, prehistoric populations and settlement pattern models and the probable nature of resultant archaeological deposits. These factors determine the archaeological resource associated with submerged prehistoric landscapes; they dictate the character of the material culture that may be encountered by marine aggregate dredging and are central to how that archaeological resource should be perceived.

As a result, submerged prehistoric landscapes ought not be conceived as 'landscapes', but as cumulative pieces of landsurfaces and deposits from different periods that have possibly been subsequently affected by transgressive/regressive cycles. The potential for surviving landsurfaces that might be complete enough to be described as a landscape, from any period, is limited and the likelihood of finding enough material to constitute a relict cultural landscape is very low. Rather, work should take into account:

- the truncated and modified nature of the remnant stratigraphic architecture;
- the importance of spatial and temporal resolution to understand this material;
- the material difference between the potential Lower and Middle Palaeolithic resource and possible Upper Palaeolithic and Mesolithic archaeology. They constitute different timescales, species and characteristic archaeological records divided by the Devensian glaciation.

Accordingly, present environmental conditions cannot be applied to the understanding of past landscapes. Environmental conditions are the result of integrated systems, where individual factors will influence and feed change in other areas. These are, however, tractable issues that can be modelled to lesser or greater degrees with the relevant baseline information.

Palaeodemography provides broad models of likely periods during which submerged remnant landscapes could have been occupied. The resolution of these hypotheses of population movement is, however, such that they can only indicate potential occupation of particular areas. They do not apply on a human scale and cannot take account of particular environmental or geographical niches or the speed of the migration of groups away from areas. They necessarily involve certain assumptions and are, importantly, only based upon the current archaeological record, which does not include material from submerged prehistoric landscapes. However, these models demonstrate that there are large periods of time when Britain, the English Channel and southern North Sea region would have been occupied.

Characterising potential activity and broad patterns of behaviour is central in order to assess potential archaeological deposits. At the same time, understanding the limitations of these models, analogies and sources is equally important. These issues have a particularly potent influence on how the potential archaeological resource is conceived and therefore evaluated, and the scale at which they are applied is therefore crucially important.

The theoretical discussion of the baseline information highlights the importance of empirical investigations. It shows that initial hypotheses need to be interrogated and a more systematically-acquired dataset, on which to develop further hypotheses, is required.

The discussion demonstrates the difficulties inherent to broad scale predictive modelling of the English Channel and southern North Sea regions in order to prospect for archaeological sites. The variable factors at regional scales are still too numerous to produce anything other than a 'speculative survey'. This also points to the consequent value of an area-specific, palaeogeographic reconstruction approach at a much smaller scale but higher resolution, an approach that matches the archaeological evaluation of aggregate areas.

Consequently, the 'Seabed Prehistory' project focused on the small scale and high resolution analysis of five different study areas either in the North Sea (Humber, Great Yarmouth, Happisburgh and Pakefield) or the English Channel (Arun, Eastern English Channel).

The comparative methodological assessment highlights the importance of the combination of geophysical and geotechnical sources for palaeogeographic evaluation. Geophysical models inform the strategy for environmental sampling and analysis, and the results can be used to refine the geophysical models. Integrated use of these sources is central to the development of more reliable palaeogeographic characterisations. Moreover, this work demonstrates how these palaeogeographies can be reconstructed, and how they may have been inhabited, and thus provide a more supportable assessment of the potential for archaeological impacts to arise from aggregate extraction.

Pleistocene seabed sediments deposited after the earliest known occupation of north-west Europe (*c.* 700 ka) are considered to have archaeological potential. Possible archaeological finds recovered by grab sampling and vibrocoring included charcoal and flint. In the Arun area possible flint and charcoal were recovered by grab sampling. The charcoal, stratified within a peat deposit currently exposed on the seabed is dated to the early Mesolithic period. Charcoal recovered from vibrocoring in the Great Yarmouth area probably dates to the Palaeolithic period and possibly the Ipswichian interglacial.

Sediments relating to shallow marine, estuarine, fluvial, terrestrial and glacial environments were recovered dating from the Cromerian Complex to recent periods. Many of these deposits date to periods when sea level, chronology, climate and environment may have been conducive to habitation during the Palaeolithic and Mesolithic. Those deposits of particular note comprise evidence relating to former landsurfaces (peat, oxidised gravels and gleyed clay), freshwater bodies (rivers and small lakes), coastal and estuarine environments. Those study areas of greatest geoarchaeological potential appear to be the Arun, the Eastern English Channel and the Great Yarmouth study area.

Extraction of gravel and sand by marine aggregate dredging will affect any prehistoric archaeological remains which occur within them. Pleistocene sands and gravels deposited by marine and particularly fluvial processes are both potential aggregate and archaeological resources. Supplying demand for marine aggregates will increasingly remove Pleistocene sediments from the seabed and any related archaeology. An effect of this, in conjunction with associated archaeological study of aggregate extraction areas, should be to provide industry, archaeologists and the public with a greater understanding of our origins.

SEABED PREHISTORY R2

FINAL REPORT

VOLUME I: INTRODUCTION

Ref. 57422.31

Acknowledgements

This project was commissioned by English Heritage. Wessex Archaeology would like to thank Kath Buxton, Dr Helen Keeley and Dr Virginia Dellino-Musgrave of English Heritage for their help and assistance throughout.

The assistance provided by Kate Barton and Derren Creswell of the Mineral Industry Research Organisation in the execution and management of the MIRO funded phases of the project is gratefully acknowledged.

The support, guidance and advice of Dr Ian Selby, Mark Russell and Dr Andrew Bellamy on the part of the aggregate industry, is gratefully acknowledged.

We would also like to thank the steering group composed of Dr Gustav Milne, Dr Bryony Coles, Simon Thorpe, Veryan Heal and Matt Tanner for their comments on the project as it progressed.

We would also like to thank our environmental specialists, particularly Dr. Rob Scaife from the University of Southampton for his dedication to this project.

The geophysical work for this project was conducted for WA by Dr Paul Baggaley, Louise Tizzard, Dr Stephanie Arnott and Cristina Serra. The environmental work for this project was conducted for WA by John Russell, Dr Chris Stevens, Dr Cathy Chisham, Dr Mike Allen and Jesse Ransley. The illustrations for this report were prepared for WA by Karen Nichols, Kitty Brandon, Tom Goskar and Lynda Coleman. Dr Paul Baggaley, John Russell and Niall Callan compiled the project-related website.

This report was written by Jesse Ransley, Louise Tizzard, John Russell and Dr Dietlind Paddenberg. It was edited by Dr Dietlind Paddenberg. The project was managed for WA by Stuart Leather. Dr Antony Firth, Head of Coastal and Marine, and Steve Webster, Senior Manager, provided internal guidance, advice and quality assurance throughout the project.

SEABED PREHISTORY R2

FINAL REPORT

VOLUME I: INTRODUCTION

Ref. 57422.31

Table of Contents

Figures

Tables

SEABED PREHISTORY R2

FINAL REPORT

VOLUME I: INTRODUCTION

Ref. 57422.31

1. INTRODUCTION

1.1. PROJECT BACKGROUND

1.1.1. Wessex Archaeology (WA) was commissioned by English Heritage (EH) to undertake the research project 'Seabed Prehistory Round 2– Gauging the Effects of Marine Aggregate Dredging', funded through Round 2 of the Aggregate Levy Sustainability Fund (ALSF) distributed by the Department for Environment, Food and Rural Affairs (Defra). The project was undertaken between February 2005 and March 2007. This project followed on from the Round 1 project 'Seabed Prehistory - Gauging the Effects of Marine Aggregate Dredging '.

1.1.2. Round 1 of the Seabed Prehistory project was commissioned by the Mineral Industries Research Organisation (MIRO). The project was undertaken between 2003 and 2004 and was part of the ALSF funded Sustainable Land Won and Marine Dredged Aggregate Minerals Programme (SAMP), administered by MIRO on behalf of the former Office of the Deputy Prime Minister (ODPM), now Department for Communities and Local Government (DCLG).

1.1.3. The 'Seabed Prehistory' project sought to address strategic gaps identified in the course of preparing Environmental Impact Assessments (EIA) for marine aggregate extraction licence applications and arose directly from WA's experience of assessing the effects of marine aggregate dredging on the marine historic environment.

1.1.4. WA has been involved in the preparation of EIAs on behalf of the marine aggregate industry since 1998 (Wessex Archaeology 1998a; 1998b). In the course of preparing these assessments it became apparent that there was a lack of knowledge regarding the survivability of prehistoric deposits of archaeological potential, and the association of these deposits with the aggregate resource. Consequently assessing impacts and proposing mitigation for these deposits could only be done for the most part on a generic level.

1.1.5. The project addressed methodologies for assessing and evaluating the potential prehistoric archaeological resource of a given area of seabed by taking industry standard geophysical and geotechnical survey methods used in the course of the environmental assessment of aggregate license areas, and applying them specifically to assessing and evaluating the potential for prehistoric archaeology within different aggregate dredging zones around the coast of the UK. The project aimed to investigate the effectiveness of the methodologies that were used as well as provide baseline data from the different aggregate zones.

1.1.6. Round 2 of the 'Seabed Prehistory' project comprised different components, each component funded through either English Heritage or MIRO, under the ALSF funding for Round 2. Each component was an independent stand alone project. However, the results of all the different components have been brought together in a series of volumes, and the results have been considered in the final volume to draw conclusions and recommendations to the aggregate industry and wider archaeological community.

1.1.7. The different components of the project are comprised in **Table I.1**.

ALSF Round	Funding Body	Component	Description
1	MIRO	Arun	Trial of geophysical and geotechnical methodologies over a section of the Palaeo-Arun river system, including geophysics, vibrocores and benthic grabbing.
2	MIRO	Arun Visualisation	A digital reconstruction of the Arun Mesolithic landscape based on the Round 1 Arun geophysical and palaeoenvironmental evidence.
2	EH	Arun Additional Grabbing	A benthic grab sampling survey for archaeological purposes extending the Round 1 Arun grab sampling survey to provide an expanded statistical sample from which to draw conclusion on hypothesis proposed in Round 1.
2	MIRO	Eastern English Channel	Trial of geophysical and geotechnical methodologies over a section of the Eastern English Channel dredging zone, including geophysics, vibrocores and benthic grabbing.
2	EH	Great Yarmouth	Trial of geophysical and geotechnical methodologies over a section of the Great Yarmouth dredging zone, including geophysics and vibrocores (no benthic grabbing was undertaken).
2	MIRO	Humber	Trial of geophysical and geotechnical methodologies over a section of the Humber dredging zone, including geophysics, vibrocores and benthic grabbing.
2	EH	Happisburgh and Pakefield Exposures	Trial use of high resolution geophysical equipment and vibrocoring (off Pakefield) to trace and identify fine-grained deposits of known archaeological potential from beach deposits excavated and recorded in a terrestrial environment offshore.
2	EH	Project Synthesis	Synthesis of all the component projects from both funding bodies.

Table I.1: Components of the Seabed Prehistory project.

1.1.8. The 'Seabed Prehistory' Round 1 project tested an integrated methodology of geophysical and geotechnical surveys focussing on the area of the Palaeo-Arun river system, off Littlehampton, Sussex, adjacent to the Owers Bank dredging zone (WA ref. 53146, March 2004). The intention of the 'Seabed Prehistory' project in Round 2 was to extend the Round 1 project to further aggregate dredging zones around the coast of the UK.

1.1.9. The MIRO-supported elements in Round 2 extended the project to aggregate dredging zones in the Eastern English Channel (WA ref. 58140.01, June 2006) and the Humber (WA ref. 58141, October 2006). Furthermore, a digital visualisation of the Arun Mesolithic environment was constructed based on the Round 1 geophysical and palaeoenvironmental data (*Internet Archaeology*, forthcoming).

1.1.10. The EH-supported parts of the Round 2 project focused on dredging zones off Great Yarmouth in Norfolk (WA ref. 57421.05, June 2006), and off Happisburgh and Pakefield in Suffolk (WA ref. 57422, October 2006). Moreover, additional grab samples from the Palaeo-Arun area were taken and assessed for the presence of archaeological material (WA ref. 57421.06, June 2006).

1.1.11. The final synthesis compiles all the component parts of the study (WA ref. 57422.10-17, March 2007). From the conclusions of the synthesis a draft guidance note has been produced to guide industry and curators in the identification and mitigation of the prehistoric archaeological resource (Wessex Archaeology 2007b). **Table I.2** provides an overview of all volumes of ‘Seabed Prehistory: Gauging the Effects of Marine Aggregate Dredging. Final Report, Volumes I-VIII’ (Wessex Archaeology 2007a), and the study locations are displayed in **Figure I.1**.

Volume	Title
I	**Introduction**
II	Arun
III	Arun Additional Grabbing
IV	Great Yarmouth
V	Eastern English Channel
VI	Humber
VII	Happisburgh and Pakefield Exposures
VIII	Results and Conclusions

Table I.2: Overview of the volume structure of this report.

1.2. MARINE AGGREGATE DREDGING AND THE HISTORIC ENVIRONMENT

1.2.1. The non-energy mineral rights to the seabed are vested in the Crown Estate. Licenses to carry out aggregate dredging are only granted by the Crown if the application receives consent from the Government through an informal ‘Government View’(GV) procedure, which is administered by the Department for Communities and Local Government (DCLG, formerly ODPM). The GV procedure is set out in Marine Minerals Guidance Note 1 (MMG 1). Since 1989, every new application has to be accompanied by an Environmental Impact Assessment (EIA).

1.2.2. The EIA addresses the potential impacts of dredging activity on all aspects of the marine environment, including the physical environment, the benthic biological resource, fish and shellfish resources, fishing activity, navigation and the historic environment. Each EIA should reflect the requirements of Environmental Impact Assessments arising from the European Council Directive 85/337/EEC as amended by Directives 97/11/EC and 2003/35/EC.

1.2.3. So far, the GV procedure is a voluntary, informal process including voluntary EIAs and incorporating the Directives mentioned above. However, failure to statutorily transpose EC Directives is likely to lead to proceedings in the European Court of

Justice and an increased risk of challenges within the UK courts. Hence, consultations have taken place since June 2006 in order to formally transpose the EC Directives in respect of marine mineral dredging. The implementation of legislation will probably take the form of Regulations, thus formalising the essential procedures of the existing informal GV system. It is anticipated that the Regulations will be in place before the end of 2007 (http://www.communities.gov.uk/pub/387/ConsultationPaperonDraftMarineMineralsDredgingRegulationsandProceduralGuidance_id1500387.pdf).

1.2.4. The archaeological component of an EIA assesses the predicted impacts on the historic environment. This involves evaluating both the maritime and the prehistoric archaeological resource. The prehistoric archaeological potential of an area is assessed in the first instance by a study of desk based sources pertaining to the area in question, and by an assessment of the geophysical and geotechnical data collected on behalf of the company undertaking the application. This provides an essentially desk based approach to assessing the prehistoric archaeological resource. On the basis of this assessment of archaeological potential, importance and predicted dredging impacts, appropriate mitigation is recommended.

1.2.5. Through the British Marine Aggregate Producer's Association (BMAPA), the aggregate industry has responded actively to these assessment requirements. In conjunction with EH and WA, BMAPA produced a 'Guidance Note on Marine Aggregate Dredging and the Historic Environment' in 2003. This publication as well as further reports (e.g. Wenban-Smith 2002) and character maps ('Palaeolithic sites chart'; 'Mesolithic sites chart') concerning the submerged prehistoric archaeological resource can be downloaded from the BMAPA website (http://www.bmapa.org/media.htm).

1.3. ASSESSING THE SUBMERGED PREHISTORIC ARCHAEOLOGICAL RESOURCE

1.3.1. The sands and gravels targeted by marine aggregate dredging were largely deposited at the end of glacial periods, when melt waters deposited vast swathes of material over the landscape. When global temperatures rose and fell sea level changed accordingly, because water was retained in the ice caps during glacial periods and released during warm phases. This resulted in dramatic changes in the landscape, with much of the now-submerged sands and gravels indicating earlier river systems and coastlines (**Figure I.1**). At different periods, these river systems and their flood plains would have formed part of landscapes occupied by the early prehistoric inhabitants of Britain and north-west Europe. It is these remnant prehistoric landscapes within the current seabed that may contain archaeological deposits and evidence of where and how our predecessors lived.

1.3.2. Seabed deposits of prehistoric interest include *in situ* deposits which have not been moved by glacial events because they were laid down from the last ice age onwards, when the climate improved, sea level rose, and people re-inhabited Britain from their continental refuges. Seabed deposits also include complex older sequences of gravels and finer grained sediments, recounting long histories of cold glacial and warm interglacial cycles, erosion and deposition, within which can be found both derived and *in situ* material telling of our predecessors' inhabitation of Britain over the last 700,000 years or more (Parfitt *et al*. 2005).

1.3.3. Generally, the submerged prehistoric archaeology of a licence application area is assessed using a combination of sources, including:

- evidence of Palaeolithic and Mesolithic activity from adjacent coastal areas;
- north-west European prehistoric population models;
- palaeolandscape evolution models, based on estimates of the topography at different points in time using current bathymetry models and estimations of sea levels as well as an assessment of geophysical and geotechnical data collected by the marine aggregate company for prospecting purposes.

1.3.4. However, the available material such as generic geological data as well as demographic archaeological hypotheses are based on the extrapolation of a limited amount of evidence over large areas, which creates constraints when assessing specific aggregate applications to exploit relatively small areas offshore (**Figure I.2**). As a result, the reconstruction of the palaeolandscape evolution which is necessary to evaluate archaeological potential, in particular, relies on the survey material collected by the marine aggregate company.

1.3.5. The archaeological consultant generally receives bathymetric and geophysical survey data to inform their assessment. These are provided in the form of isopachytes and cross sections, and are increasingly delivered in a digital format. The archaeologists may also be provided with reports from any geotechnical evaluations that have been carried out. The survey work undertaken by the aggregate company for an extraction licence application is primarily aimed at prospecting and assessing the aggregate resource, and the survey strategy and specifications consequently reflect this. This is true of both geophysical and geotechnical surveys. As a result, the information provided to archaeologists is only partly suitable to assess the cultural heritage resource.

1.3.6. The reconstruction of the palaeolandscape evolution of any aggregate licence application area employs a number of evaluation techniques. Projected sea level curves are modelled against, for example, the sub-surface horizons to identify the periods of prehistory during which the area was most likely to have been exposed, highlighting times when the area was potentially accessible to prehistoric populations (**Figure I.2**). Where possible the bathymetric and geophysical survey data collected by the aggregate company is used for this modelling, thus enabling the broad characterisation of the topographic and geological nature of the buried landsurfaces.

1.3.7. These models are then combined with evidence of prehistoric activity in adjacent coastal areas and from wider prehistoric population and settlement models, to identify periods of potential activity in the application area. This evidence is finally interrelated to the other factors regarding the potential for survival of archaeological material within seabed deposits to evaluate the prehistoric archaeological resource of an application area.

1.3.8. This methodology has acknowledged limitations and only characterises, rather than defines, the archaeological potential of an area. It has since been recognised that there is potential for fuller evaluation with better information, including archaeological input into the survey strategy or methodology as well as access to the raw and processed survey data, and geotechnical sampling.

1.3.9. This improved access resulted, for example, in the possibility of the archaeological consultant having influence on the location of geophysical survey lines. It also enabled a staged geoarchaeological approach applied by WA as it became obvious that geoarchaeological descriptions of vibrocore samples need to be more detailed than the descriptions given by industry geologists. These more complex descriptions cannot be made from core log photographs alone, but require access to the actual cores. The staged approach consists of:

- Stage 1: Planning
- Stage 2: Coring and Recording
- Stage 3: Sampling and Assessment
- Stage 4: Analysis and Dating
- Stage 5: Final Report

1.3.10. There have been very few archaeological survey projects that have attempted any kind of assessment of the submerged archaeology resource before the 'Seabed Prehistory' project. Moreover, none of the projects provided unflawed models of comprehensive evaluation techniques. There was a tendency to attempt site prediction or prospecting when archaeological survey was undertaken and there was an unarticulated post-Last Glacial Maximum (LGM) bias in the limited body of work carried out by then.

1.3.11. For example in response to changes in Danish protection of ancient monuments legislation in 1984, which extended the legislation to include 'submerged habitation sites', the Danish heritage service undertook a survey of their submerged archaeological resource (Smed 1987:111). The project had an implicit post-Devensian focus, addressing fairly 'recently' submerged Mesolithic deposits. It also took a primarily site prospecting approach, addressing surface and part-buried material, rather than buried deposits within the deeper stratigraphy, acknowledging simply 'a picture is emerging, which indicates, that some of the more deeply located sites are still preserved in the seabed' (Smed 1987:116).

1.3.12. The work undertaken by Fedje and Josenhans in the Juan Perez Sound, Queen Charlotte Islands (Haida Gwaii), off the west coast of Canada has a similar site prospecting focus, but a different methodology. The Haida Gwaii project used multibeam bathymetry to model the seabed topography and targeted specific locations with seabed grab sampling along with Remotely Operated Vehicle (ROV) and sonar surveys. Palaeogeographic reconstruction was limited, equating the seabed topography with the post-Devensian palaeolandscape. The explicit Early Post Glacial site prospecting strategy relied on this supposition and targeted remnant alluvial fans and deltas, 'factors considered in site selection included protection […], potential of associated landscape for shellfish and finfish, and proximity to fresh-water sources (paleocreeks and paleogulleys [*sic*])' (Fedje and Josenhans 2000:100).

1.3.13. Although both these projects had archaeological objectives, the methodologies were not readily applicable to the aggregate licence application process. These studies were not attempting to assess the whole prehistoric archaeological resource of a given area of seabed, but instead were attempting to identify sites of a particular type or period across a larger area. There were no other studies that had undertaken work with comparable aims and, therefore, comparable methodologies or approaches did not exist. Consequently, developing the archaeological assessment process was not only a valuable but also an innovative undertaking.

1.4. PROJECT OBJECTIVES AND APPROACH

Project Aims and Objectives

1.4.1. The aim of 'Seabed Prehistory' Round 2 was a continuation of the aim of the Round 1 project, which was to enable a better environmental assessment of the prehistoric archaeological heritage of marine aggregate deposits. The objectives were carried forward under the headings from Round 1, as follows:

- To better understand the extent and character of prehistoric seabed deposits, and therefore:
    - to establish the presence of seabed and sub-seabed palaeogeographic features in association with aggregate dredging areas;
    - to acquire detailed data on environmental context and archaeological importance of discrete deposits;
    - to test the association of the presence of prehistoric artefacts on or near the surface of the seabed with seabed and sub-seabed palaeogeographic features.
- To develop new methodologies for assessing and evaluating prehistoric seabed deposits in the course of license applications, and therefore:
    - to consolidate and further test the archaeological application of geophysical, geotechnical and benthic acquisition, recording, processing and interpretation methods suitable for adoption by industry;
    - to develop dating and environmental sampling strategies;
    - to develop methods adoptable by industry for achieving an absolute outline chronology of coarse sediment deposition.
- To guide industry, regulators and public towards better understanding, conservation and appreciation of prehistoric seabed deposits implicated by marine aggregate dredging, and therefore:
    - to communicate the knowledge gain from this project to public and professional audiences;
    - to raise public awareness of the conservation issues arising from the impact of marine aggregate extraction on the prehistoric environment;
    - to promote information exchange between this project and related projects, and between industry, regulators, curators and contractors;
    - to develop and promote the uptake of best practice.

1.4.2. The overall objectives of the SAMP programme included:

- Improving the information base on environmental constraints so that sustainable options can be identified;
- Supporting the improvement of environmental management practices so that impacts can be reduced;
- Assisting in providing information and examples of good practice to stakeholders.

Approach and Methodology

1.4.3. The project addressed the potential for prehistoric deposits of specific areas of seabed by assessing and applying industry standard geophysical and geotechnical tools for archaeological evaluation. The project also sought to test the effectiveness of assessment methodologies applicable to the licence application process. As such, it aimed to demonstrate the potential of this kind of archaeological evaluation to elucidate the evidence for prehistoric landscapes, which are now buried under the seabed.

1.4.4. In order to achieve this, a series of survey methodologies were undertaken which comprised:

- Bathymetric surveys which allowed to establish water depth and geomorphology of the current seabed;
- Sidescan sonar surveys which allowed the seafloor sediments to be interpreted;
- Shallow seismic surveys which allowed the sub-surface geology to be interpreted and individual geophysical horizons to be digitally modelled;
- A judgement-led vibrocoring programme based on the results of the geophysical data, allowing calibration in terms of the sediment stratigraphy, of the identified geophysical horizons and providing samples for environmental analysis and dating;
- The integration of the information from the geophysical survey and the vibrocore programme enabling the reconstruction of palaeolandsurfaces;
- A systematic grab sampling programme over part of the study area to assess the probability of locating artefacts and exposed fine-grained sediments within the top layer of seabed.

1.4.5. The project focussed on area evaluation rather than archaeological site inspection. However, the approach did not pursue broad, theoretical and predictive modelling, which at this early stage of research into submerged prehistoric deposits would have remained problematic. Rather modelling and reconstruction was focused on a defined, localised area and based upon specific, empirical data, providing more practical and implementable conclusions that address the pragmatic and immediate requirements of assessing archaeologically the licence application.

1.4.6. The project methodology took techniques that were relatively well-established in archaeological practice and/or the marine industry and combined and reapplied them to the evaluation of submerged prehistoric deposits. The overall evaluation method involved:

- palaeogeomorphological modelling using geophysical survey data;
- palaeogeoarchaeological reconstruction from geotechnical survey data;
- the combination of both datasets and the development of a chronology;
- the assessment of the potential for human activity assisted by the analysis of the grab sampling programme;
- the resultant characterisation and partial visualisation of the potential archaeological resource of the study area.

This approach included the testing and assessing of potential variations within the survey and reconstruction process of the palaeogeographic evolution, thus demonstrating the value of this kind of holistic strategy.

1.5. STEERING GROUP

1.5.1. Integral to the project's approach was an active engagement with the developing study of prehistoric submerged deposits and its related management issues. This involved an ongoing formal and informal consultation process with:

- the members of the Project Steering Group including representatives of the marine aggregate industry, academic and curatorial bodies. The Steering Group comprised Dr. Ian Selby (Hanson Aggregates Marine Limited), Dr. Andrew Bellamy (United Marine Aggregates Limited), Mark Russell (BMAPA), Dr Gustav Milne (University College London), Dr Bryony Coles (University of Exeter), Simon Thorpe (Cornwall HER), Veryan Heal (Cornwall HER) and Matt Tanner (SS Great Britain);
- individual researchers in related Quaternary archaeological and science fields, the majority of whom are pursuing other ALSF-funded research projects, including Dr Martin Bates (University of Wales), Dr Justin Dix (Southampton Oceanography Centre and University of Southampton), Dr Rob Hosfield (University of Reading), Dr Antony Long (Durham University) and Dr Rob Scaife (University of Southampton), Dr Ceri James (BGS), Prof Jim Rose (University of London), Dr Simon Parfitt (Natural History Museum and University College London) and Dr Brian D'Ollier.

1.6. OUTREACH AND DISSEMINATION

1.6.1. Both the project methodology and conclusions have been presented to a wider audience through a series of conference and seminar papers and posters. These have included industry and regulators as well as the research community, including:

- The 'North Sea in Prehistory Workshop' at the Royal Society in London (May 2003);

- The ‘Marine Geoarchaeology Work in Progress Seminar’ at the London Geological Society (November 2003), organised by the Maritime Studies Group of the Geological Society and WA. The aim of this seminar was to facilitate wider dissemination and debate the current level of academic research into the submerged prehistory in Northern Europe;

- The ‘Environment and Aggregate-Related Archaeology Seminar Day’ (February 2004);

- The ‘Seabed and Shallow Section Marine Geoscience Conference’ at the Geological Society in London (February 2004);

- The ‘Aggregates Levy Sustainability Fund Meeting’ organised by English Heritage at Savile Row in London (March 2005);

- The ‘National Archaeology Week’ at Salisbury Museum (July 2005);

- The ‘Marine Aggregate Levy Sustainability Fund Conference’ at the School of Oriental and African Studies (SOAS) in London (July 2005);

- The Association of Environmental Archaeologists ‘Visualising Past Environments’ conference at the University of Hull (November 2005);

- The ‘19th International Radiocarbon Conference’ at Keble College in Oxford (March 2006);

- The ‘Marine Aggregate Levy Sustainability Fund Conference’ at the University of Southampton (September 2006);

- The annual meeting of the ‘Arbeitskreis für Unterwasserarchäologie (AKUWA)’ (association of German, Swiss, Austrian and French underwater archaeologists) at the Département des Recherches Archéologiques Subaquatiques et Sous-Marines (DRASSM) in Annecy, France (October 2006);

- A talk to the ‘Norfolk and Norwich Archaeological Society’ as part of the winter lectures programme at the Castle Museum in Norwich (November 2006);

- Environmental and Industrial Geophysics Group (EIGG) ‘Recent works in Archaeological Geophysics’ Conference at the Geological Society in London (December 2006);

- The ‘Great Yarmouth Archaeological Society Meeting’ at the Central Library in Great Yarmouth (February 2007);

- ‘Advances in Geophysics’ conference by the British Geophysics Association at the Geological Society in London (February 2007);

- A talk to the ‘Grimsby Branch of the Historical Association’ at the Central Library in Grimsby (March 2007);

- A talk to Maritime Archaeology students at the University of Kiel, Germany (May 2007);

- As well as these formal seminars and talks, in-house 'Postgraduate Students Seminar Days' for students from Bristol and Southampton Universities were held in December 2003, February 2005, March 2006 and March 2007 at WA's premises in Salisbury.

1.6.2. This programme of dissemination resulted in two-way communication. Project results were presented in part to elicit responses to ideas so that an informal consultation process was maintained. This process continues with the publication of project conclusions in academic journals. Furthermore, a recommended best practice summary of the methodological guidelines for industry was presented as a Draft Technical Advice Note in 2004, and an updated version of this has been submitted (Wessex Archaeology 2007b).

2. BASELINE ENVIRONMENT – MARINE GEOARCHAEOLOGY AND SUBMERGED PREHISTORIC LANDSCAPES

2.1. INTRODUCTION

2.1.1. This chapter sets out the problems surrounding the submerged prehistoric archaeology, including questions of the identification and assessment of timescales, cyclical climate change and its consequences, prehistoric populations and 'settlement pattern' models, and the probable nature of resultant archaeological deposits. These factors determine the archaeological resource associated with submerged prehistoric landscapes; they dictate the character of the material culture that may be encountered by marine aggregate dredging and are central to how that archaeological resource should be perceived.

2.1.2. The aim of the following chapter is to illuminate the constraints and complexities associated with the general study area in the English Channel and the southern North Sea. The chapter provides a summary of the baseline information and thereby an appropriate background to both the developing, inter-disciplinary field and the specific methodological questions this project is addressing. However, if a fuller discussion is sought, a multi-disciplinary and inclusive 'Reassessment of the Archaeological Potential of Continental Shelves' was the focus of another ASLF project undertaken by Southampton University (Dix and Westley 2004).

2.2. PALAEOGEOGRAPHIC RECONSTRUCTION

Time Scales and Scales of Resolution

2.2.1. Reconstructing submerged remnant prehistoric landsurfaces is a complex task. The English Channel, the southern North Sea and other sea areas around the UK were exposed periodically throughout the early prehistoric period from *c.* 700 to 5 ka. Consequently, there is approximately 700,000 years of potential activity, archaeology and information represented by submerged remnant landscapes. **Table I.3** illustrates the approximate Quaternary chronology according to Stringer and

Gamble (1993:148), Barton (1997: Table 7), Wymer (1999: Table 2), Hosfield (2005:23) and Parfitt *et al*. (2005:1011).

General Date Range	Archaeological Period	Key Glacial Events
8,500-6,000 BP (7,500 – 4,800 cal. BC)	Late Mesolithic	*c.* 10,000 BP (9,600 cal. BC) post-Devensian period/ Post-Glacial begins
10,000-8,500 BP (9,600 – 7,500 cal. BC)	Early Mesolithic	
40,000-10,000 BP (9,600 cal. BC)	Upper Palaeolithic	*c.* 12,000 BP (11,800 cal. BC) Late Glacial begins
		c. 18,000 BP (19,300 cal. BC) Devensian (=Last) Glacial Maximum (LGM)
250/200 ka - 40 ka	Middle Palaeolithic	*c.* 110 ka Devensian glaciation begins
700 - 250/200 ka	Lower Palaeolithic	Earlier glaciations (see table below)

Table I.3: Approximate Quaternary chronology.

2.2.2. This extensive period of time is broadly divided into Lower (700-250/200 ka), Middle (250/200-40 ka) and Upper (40-10ka) Palaeolithic periods and the Mesolithic (10,000-6,000 BP/ 9,600 – 4,800 cal. BC). There are significantly different scales of resolution between the Lower and Middle Palaeolithic and the Upper Palaeolithic and Mesolithic, which are most usefully divided by the last glaciation, the Devensian.

2.2.3. In the pre-Devensian period interpretations can be made about broad 'cultural' divisions defined by changes in lithic technology, which can cover hundreds of thousands of years. These broad 'cultural' divisions also mask the extremes experienced in climate change, represented in the sedimentary record over this vast period of time.

2.2.4. In the post-Devensian period timescales become smaller and in some cases the activities of individual social groups can be interpreted. These changes in timescales are mirrored by more focused spatial scales and consequently, there is an increase in resolution as interpretations move forward through time.

Glacial Cycles, Sea Level Change and Marine Transgressions

2.2.5. Throughout the early prehistoric period climate change resulted in a series of glacial and interglacial periods. This cycle of climatic warm and cold periods alternately locked up and then released large amounts of water in ice caps causing relative sea level change. Changes in relative sea level caused marine transgressions and regressions, inundating and exposing areas of land/seabed.

2.2.6. This global, or eustatic, sea level change 'signal' can be modelled using analysis of deep sea cores, representing changes in overall ocean volume (Siddall *et al.* 2003). Global sea level curves can be mapped against current seabed bathymetry to produce a broad resolution model of periods when the Channel and southern North Sea region were exposed and flooded (see **Figure I.2**).

2.2.7. Global curves are regularly being refined, and can vary significantly depending on their source material. However, given the low resolution of the resulting models, they can still only be used to identify periods at which the current seabed would have been exposed. For example, the model produced by Shennan *et al.* (2000), accommodated global sea level alongside a tidal model, but was forced to rely on current seabed bathymetric topography as the model for prehistoric landsurfaces. As a result, despite the more refined sea level curve, the resultant model is materially little different from Jelgermas (1979, p240 Figure V-12) model for the Danish North Sea coast (A. Long pers. comm.).

2.2.8. On a regional scale isostatic variations can affect the sea level curve. As a result of the melting of ice caps and the consequent removal of weight from land masses, 'rebound' occurs as land masses readjust. This glacio-isostasy is probably the most widely known factor, since rebound has caused the north-east of the UK to experience a post-glacial relative sea level fall whilst the south-west has experienced rising sea levels (Waller and Long 2003). On a more local level, the balance between sediment supply and relative sea level change, hydro-isostasy, can often be the driving factor along with the effects of fluvial systems (Long 2003:429-430; Shennan *et al*. 2002a).

2.2.9. At a local scale, sea level change can be identified in the sedimentary record. Local sea level index points, confirmed local sea levels at given periods, are therefore most effective for modelling sea level change. However, as yet these are all confined to coastal areas and though there is a significant body of work along the south coast of England, there are no offshore index points, and coastal points must be extrapolated offshore.

2.2.10. **Table I.4** provides an approximate indication of global sea level variations during the last 800,000 years. It is based on several references. The Oxygen Isotope Stages are from Wymer's projection in 'The Lower Palaeolithic Occupation of Britain' (1999:4 Table 2) and from compilations by Dix and Westley (2004:95 Figure 64) and the Ancient Human Occupation of Britain (AHOB) project (AHOB 2006; e.g. Barton 2005:18 Table 2). The sea levels for the Pleistocene period are drawn from discussions by Funnel (1995:4 Figure 1), Dix and Westley (2004:67-80) and Lee *et al*. (2006:173-176). For the Holocene period, more data are available especially for the east and the south coasts of England and the western North Sea (Shennan *et al.* 2002b:278 Figure 3). However, it should be kept in mind that sea level curves generally rely on diversified calculations of manifold factors and therefore often reflect a general tendency rather than exact figures.

2.2.11. **Table I.4** also illustrates the relationships between the major archaeological periods in Britain and the last glaciation, the Devensian, which is marked by shading. Furthermore, the major depositional horizons of gravel terraces in the Middle and Lower Thames valley after Bridgland (1994; *et al.* 2004) and Wymer (1999:57 Table 6) are indicated. In contrast to other river terraces such as the Solent sequence, fossil-bearing sediments have provided some dating-control in the Thames, and other river sequences are generally dated by correlation to the Thames sequence (Bridgland 2001:19). Finally, the temporary island status of Britain according to White and Schreve (2000:12) - as opposed to peninsularity as the predominant status.

2.2.12. In **Table I.4** approximate ages within the radiocarbon dating scale (*c.* 50,000 radiocarbon yrs) are defined as BP (uncalibrated radiocarbon age), those dates within the radiocarbon calibration range (< 22,000 yrs) are also given in calendar years BC (cal. BC). Those dates older than 50,000 yrs are referred to in terms of ka (thousand years).

Relative Sea Level	Approximate Age	Oxygen Isotope Stage	Chronozone/ Biozone	Archaeology
0m+ to -10m+	5,500 BP (4,300 cal. BC) 7,200 BP (6,000 cal. BC)	-	Atlantic pollen zone	Late Mesolithic to Early Neolithic
-15m+	- 8,500 BP (7,500 cal. BC)	-	Boreal pollen zone	Beginning of Late Mesolithic, land-bridge to the continent finally removed
-30m+	- 9,500 BP (8,800 cal. BC)	-	Boreal pollen zone	Early Mesolithic
-40m+	- 10,000 BP (9,600 cal. BC)	-	Preboreal pollen zone	Beginning of Early Mesolithic
-50m+	- 11,000 BP (10,900 cal. BC)	1	Loch Lomond stadial	Final Upper Palaeolithic
-60m+	- 13,500 BP (14,100 cal. BC)	2	Windermere interstadial/ Late glacial	Late to Final Upper Palaeolithic, Re-colonisation of Britain from *c.* 12,500 BP (12,700 cal. BC); Creswellian cave sites and 'straight-backed blade' open air sites at Brockhill and Hengistbury Head
-80 to -100m+	- 18,000 BP (19,300 cal. BC)	2	Dimlington stadial/ Late Devensian glaciation	Mid to Late Upper Palaeolithic, Britain probably not occupied
-120m+	- 40,000 BP	2	Devensian glacial maximum *c.* 18,000 BP (19,300 cal. BC)	Early to Mid Upper Palaeolithic, appearance of modern humans in Europe *c.* 40-30,000 BP; Britain probably not occupied from *c.* 22,000 BP
-60 to -90m+	- 110 ka	3-5a-d	Devensian glaciation, Upton Warren/Chelford interstadials	Late Middle Palaeolithic; Kempton Park/East Tilbury gravel terraces deposited; Britain probably not occupied until 60 ka
0m+	- 130 ka	5e	Ipswichian interglacial	Early Middle Palaeolithic; Britain is an island and probably not occupied; raised beach deposits, e.g. Pagham

Relative Sea Level	Approximate Age	Oxygen Isotope Stage	Chronozone/ Biozone	Archaeology
-120m+	- 186 ka	6	Wolstonian glaciation	Taplow/Mucking gravel terraces deposited; Britain probably not occupied from 180 ka
0m+	- 245 ka	7	(Aveley) interglacial	Pontnewydd (Homo neanderthalensis); Britain is an island; Norton raised beach
-120m+	- 303 ka	8	Wolstonian glaciation	Lynch Hill/Corbets Tey gravel terraces deposited – possibly related to the particularly artefact rich Taddiford Farm Gravel of the Solent; Levallois technology appears
0m+	- 339 ka	9	(Purfleet) interglacial	Sparsity of sites; Britain probably an island for at least part of this stage
-120m+	- 380 ka	10	Wolstonian glaciation	Boyn Hill/Orset Heath gravel terraces deposited; many Lower Palaeolithic sites
0m+	- 423 ka	11	Hoxnian interglacial	Swanscombe (Homo heidelbergensis); Aldingbourne raised beach (? possibly early OIS 7); Britain is an island during late Hoxnian
-130m+	- 478 ka	12	Anglian glaciation	Sea level probably at its lowest recorded level around the British Isles; first breach of continental land-bridge during late Anglian
+/-0m	- 528 ka	13	Cromerian Complex, including Cromer Forest-bed formation (possibly confined to OIS 17-19) and Happisburgh glaciation (OIS 16?)	Boxgrove (Homo heidelbergensis); Slindon raised beach
-50m	- 568 ka	14		
+/-0m	- 621 ka	15		
-90m	- 659 ka	16		
-10m	- 712 ka	17		Happisburgh artefacts
-80m	- 760 ka	18		
-?m	- ?	19		Pakefield freshwater deposits and artefacts (OIS 17 or 19?)
+/-0m	- 787 ka			Pakefield estuarine deposits and artefacts (OIS 17 or 19?)

Table I.4: Relationships between age, archaeology and relative sea level from the Cromerian Complex to post-Devensian.

2.2.13. During the multiple cycles of transgressions and regressions, associated with the transitions between glacial and interglacial phases, various areas of the southern North Sea and English Channel were repeatedly exposed. During these transitions, sediments would have been reworked, primarily through the repeated combination of fluvial action, glacial and permafrost melts, followed by marine transgression. Moreover, glacial cycles did not follow a regular pattern and within the transition from glacial to interglacial, with its progressive warming of the environment, there would have been short periods of cooling. As a consequence, the pattern of inundation and exposure would have occurred irregularly at varying rates, within an overall transgression or regression trend.

2.2.14. The consequence of these multiple cycles of transgression and regression is that in some cases deposits within the seabed around the UK have been truncated and sequences of earlier deposits have been isolated. The present day seabed stratigraphy does not necessarily represent a complete chronological sequence as deposits may have been completely or partially eroded before subsequent deposition. As well as the possibility of some periods of deposition not being represented in the sedimentary record, some deposits may have been reworked and modified by flooding events.

2.2.15. Therefore, it should be noted that modelling palaeogeographies is complex and requires the broadest resolution. Submerged prehistoric landscapes ought not therefore be conceived as 'landscapes', but as cumulative pieces of landsurfaces and deposits from different periods that have possibly been subsequently truncated/eroded by transgression.

Environmental Change

2.2.16. Driven by climate change and associated sea level change, the cycle of transgressions and regressions would have had various effects on the environment.

2.2.17. Ecological and weather systems would have moved south during periods of glaciation and north in warmer interglacial periods (**Figure I.3**). This would have resulted in changes in habitat and temperatures, although there would have also been wider related consequences. For example, the exposed English Channel 'floodplain' would have been a tundra environment within a permafrost zone during late glacial periods, warming up to a more estuarine, coastal plain dominated by rivers and lakes in interglacial periods.

2.2.18. The shifts in the weather system and the position of the coast would have led to changes in wave patterns, altered the fetch, and resulted in different tidal regimes. Climate change would also have affected hydrological regimes within the coastal plain. Changes to ground water level and subterranean aquifers can cause dramatic effects on the development of wetlands. The river systems themselves would have probably been more dynamic during late glacial and post glacial periods, specifically during transitions between the warm and cold periods, transporting large amounts of periglacial, and possibly glacial, meltwater with large quantities of sediments.

2.2.19. In short, present environmental conditions cannot be applied to the understanding of past landscapes. Environmental conditions are the result of integrated systems, where individual factors will influence and feed change in other areas. These are, however, tractable issues that can be modelled to lesser or greater degrees with the relevant baseline information.

2.3. THE WIDER ARCHAEOLOGICAL CONTEXT: NORTHERN EUROPE POPULATIONS

2.3.1. Crucial to the assessment of the archaeological potential of these remnant palaeogeographies is evaluating the likely human presence in these environments during the appropriate periods. There are models available of past hominin populations drawn from the wider European archaeological record (known as palaeodemography). There are, nonetheless, 'recurring problems in archaeological demography such as the quality of sampling (never sufficient) and the uniformitarian assumption (always bold)' (Bocquet-Appel and Demars 2000:552).

2.3.2. The archaeological record is inherently biased, because less evidence survives from earlier periods. There are only between 17 and 20 Lower and Middle Palaeolithic primary terrestrial sites (as opposed to lithic findspots) in Britain (R. Hosfield pers. comm.), and we cannot quantify what is absent from the archaeological record. However, these models can identify broad periods of hominin presence and absence from certain areas. Hence, the following is a broad population summary drawn from a number of sources (Bocquet-Appel and Demars 2000; White and Schreve 2000; Ashton and Lewis 2002; Housley *et al.* 1997; Blackwell and Buck 2003; Ashton 1983).

Lower and Middle Palaeolithic (700-40 ka)

2.3.3. During the Lower and Middle Palaeolithic, the archaeological record relates to a number of different, hominin species, including the ancestors of modern humans and Neanderthal populations. The term hominin is therefore used here to include all these species including *Homo sapiens sapiens* (as opposed to hominids, which additionally include the African great apes: Stringer 2006:25; Klein 1999).

2.3.4. There is evidence of hominin groups in southern Europe from as early as 800 ka. Until recently, the earliest uncontested artefacts from northern Europe were much younger, suggesting that humans were unable to colonise northern latitudes until *c.* 500 ka. However, recent investigations in Pakefield and Happisburgh in East Anglia revealed flint artefacts dating back to *c.* 700 ka, thus presenting not only the oldest known British evidence, but also the oldest known evidence of hominins in northern Europe (Parfitt *et al.* 2005).

2.3.5. Artefact densities in fluvial gravel terraces suggest that populations in Britain were at a peak during the Anglian and the Hoxnian Stage (*c.* 500-350 ka). There is evidence that there then followed a period of depopulation in Britain. Presumably there were gradually declining populations in each successive period of settlement between *c.* 350 and 200 ka. The transition from the Lower Palaeolithic to the Middle Palaeolithic period took place between *c.* 250 and 200 ka. For most of the Middle Palaeolithic, 180 and 60 ka, there is a complete absence of evidence of hominins in the British archaeological record (Ashton and Lewis 2002:390-1).

2.3.6. In order to address this period of absence, Ashton and Lewis (2002) have modelled periods of potential occupation of Britain, and therefore the submerged remnant landscapes of the Channel, based upon global sea level (access to Britain via landbridge) and climatic conditions (suitable environment). They argue that the formation of the English Channel 'changed the cycle and stability of human occupation, through the sensitive interplay of sea level and climate change' and that with changing hominin habitat preferences 'Britain and north-west Europe became less attractive for colonisation, except in cool, open conditions' (Ashton and Lewis 2002:394-5). Their model suggests that occupation was possible for approximately a third of the overall Lower and Middle Palaeolithic period.

2.3.7. The re-colonisation of Britain began around 60 ka, during the later Middle Palaeolithic, although the chronology of this transitional period is still poorly understood. According to estimations of migration processes, modern humans probably began to colonise Europe between 40 and 30,000 BP (Mellars 2006). However, the allegedly 40,000 year old skeletons from Cro-Magnon in France have recently been radiocarbon re-dated to about 30,000 BP. Hence, the so far oldest skeletal find of *homo sapiens* in the European archaeological record is a Czech example dating back to *c.* 31,000 BP (Wild *et al*. 2005).

Upper Palaeolithic and Mesolithic (40,000-6,000 BP/4,800 cal. BC)

2.3.8. This is a dynamic period involving refuge and re-colonisation, followed by the last period of marine transgression and the final separation from continental Europe around 8,500 BP (7,500 cal. BC). It is also the period when the combination of the available archaeological resource, a comparatively limited timescale, and existing knowledge about cultural groups allow us to formulate population models that focus more easily on human factors and human action.

2.3.9. According to the gap in the archaeological record, Britain was probably not occupied between *c.* 22,000 BP and 13,000 BP (13,300 cal. BC), around the Devensian glacial maximum (Housley *et al.* 1997:43; Bridgland 2000:1300). During this 'refuge' period northern European populations appear to have migrated towards central Europe as a result of climate change.

2.3.10. The final re-colonisation occurred after the last glacial maximum at *c.* 18,000 BP, beginning at *c.* 13,000 BP (13,300 cal. BC). Housley *et al.* (1997:25) argue that it was 'a dynamic process, integral to, and internally driven by, the social life of Lateglacial hunters'. This means, colonisation was a process rather than an event, with an initial 'pioneer phase', when only a few small hunting parties moved to explore and exploit the previously unpopulated area. This phase lasted about 400 to 600 years and was followed by the establishment of larger, but possibly not permanent, occupation sites during the 'residential camp phase' from *c.* 12,500 BP (12,700 cal. BC) onwards (Housley *et al.* 1997:44-5).

2.3.11. This last period of re-colonisation - as well as the previous ones - would necessarily have included occupation of the now-submerged Channel and southern North Sea region, and the following rates of expansion from refuge areas might reasonably be applied here as well. Housley *et al.* (1997:47) came to the conclusion that the regular pattern of the Palaeolithic re-colonisation of northern Europe can be compared with rates proposed for the spread of Neolithic European farmers, estimated to about 1 km per year based on the assumption that individuals dispersed randomly in all directions.

2.3.12. In the following period of time, the archaeological record is characterised by the cultural shift from the Upper Palaeolithic to Mesolithic culture and the appearance of microlithic technologies around 10,000 BP (9,600 cal. BC). This is the only period represented by the known submerged archaeological resource; in fact the majority of this material dates to the very last period of Mesolithic activity prior to inundation at around 8,500 BP (7,500 cal. BC). This highlights the potential significance of any material from earlier periods.

2.3.13. Palaeodemography provides broad models of likely periods during which submerged remnant landscapes could have been occupied. The resolution of these hypotheses of population movement is, however, such that they can only indicate potential occupation of particular areas. They do not apply on a human scale and cannot take account of particular environmental or geographical niches or the speed of the migration of groups away from areas. They necessarily involve certain assumptions and are, importantly, only based upon the current archaeological record, which does not include material from submerged prehistoric landscapes. However, these models demonstrate that there are large periods of time when Britain, the English Channel and southern North Sea region would have been occupied.

2.4. SUBMERGED PREHISTORIC ARCHAEOLOGY

2.4.1. The periodic peninsularity of the British Isles has been discussed by Quaternary geologists for a number of decades and is widely accepted; 'it is generally believed that Britain last became separated from mainland Europe about 8500 years ago' (Preece 1995b:1). However, although the potential for submerged prehistoric archaeology was probably expressed as early as 1872, it was more fully articulated in 1998 (Lyell 1872; Coles 1998).

2.4.2. So far, there are only two archaeologically investigated submerged prehistoric sites in UK waters. Both sites are Mesolithic in age and lie in shallow, coastal waters. The site at Bouldner Cliff, Isle of Wight, is eroding out from a submerged cliff and comprises peat, a submerged forest, a hearth and over 300 worked and burnt flints (Momber 2000; 2001; 2004:40; 2006:60; Momber and Campbell 2005). Another recently discovered site in Brown's Bay off Tynemouth consists of underwater 'scatters' of flint artefacts and is two-phase, comprising an early Mesolithic find assemblage further out to sea and a late Mesolithic artefact scatter closer onshore (Moran 2003). Altogether 30 artefacts were recovered from Brown Bay during a brief dive season in summer 2003, all of which had signs of water rolling and attrition (Spikins 2003 'Marine Geoarchaeology Conference' paper).

2.4.3. There are also a significant number of northern European submerged prehistoric sites. The sites in the Baltic region are the most widely investigated and published submerged prehistoric archaeological deposits (Fischer 1995; Malm 1995; Skaarup 1995, Grøn 1995; Hansen 1995; Lübke 2002). They represent a singular record of Scandinavian coastal exploitation during the Mesolithic period. They are shallow water, coastal sites, which were relatively recently submerged, but have produced an unprecedented range of preserved organic finds, including dwelling structures, graves, logboats, fishing equipment, bone, stone and animal product artefacts (Skaarup 1995). A number of British Mesolithic sites have been discovered during intertidal research such as in the Severn Estuary (Bell *et al*. 2000:33-63), indicating the potential for a similar preservation as in the submerged Baltic record.

2.4.4. Even though proper burial sites such as Tybrind Vig in Denmark (Malm 1995:392; see Fischer 2004:27 and Grøn and Skaarup 2004:54 for further sites) are not known so far on the British Isles, there is evidence for skull deposition in coastal wetland contexts since the Neolithic in England and Wales (King 2006), and eroded burials date to prehistoric periods as well (Bell *et al.* 2000:71). One of them is the Neolithic skeleton discovered in the peat in Hartlepool Bay in north-east England in 1971. The man was between 25 and 35 years old and had been placed in a crouched position on his right side. A small group of flint flakes had been placed near his elbow, and there was some evidence that the body had been covered with branches and twigs of birch (Waughman 2005).

2.4.5. Furthermore, evidence of extensive Mesolithic coastal use can be found in Scotland, where isostatic uplift caused the creation of so-called 'raised beaches', thus preserving a number of shell middens above the present day coast (Mithen 1999:53). Extensive exploitation also applies for those coastal regions during the Mesolithic in Norway and Sweden which are above present day sea level. The sea coast was the focal area of habitation in this region at least as far back as *c.* 10,000 BP (9,600 cal. BC). As the first pioneers of the Scandinavian peninsula seemingly arrived well-acquainted with life on the coast, Fischer (2004:34) assumed that coast-adapted societies had existed long before, along the now-submerged sea shores of the North Sea and elsewhere.

2.4.6. The known northern European submerged primary sites, including the British ones, are exclusively Mesolithic or younger and coastal. However, a possibly Upper Palaeolithic flint artefact was recovered in a British Geological Survey (BGS) seabed core during the mid 1980s, from a depth of *c.* 28m below sea level (Long *et al.* 1986). The core was taken between Viking Bank and Pobie Bank in the North Sea, approximately halfway between the Shetland Islands and Norway. Though the origin of the artefact is not secure, it raised the possibility 'that it is locally derived from a site of former human habitation in the middle of what is now the Northern North Sea' (Long *et al.* 1986:55).

2.4.7. There are a number of prehistoric artefacts that have been recovered from the seabed by fishing activities, including a collection of over two hundred retrieved from the Solent by Michael White and catalogued by WA as part of the 'Artefacts from the Sea' ASLF project (WA 2003/2004). At the same time, there is also a large body of prehistoric animal bones regularly recovered by fishermen in trawl nets in the southern North Sea and the English Channel. These appear to be indications of the faunal population of the now submerged prehistoric landscapes (cf. Protocol 2006).

2.4.8. In fact, a number of Mesolithic bone and antler artefacts have been dredged up with this material including a barbed point from the Leman and Owers Banks 40km off Norfolk (Godwin and Godwin 1933) and 24 bone and antler implements from the Brown Bank area between East Anglia and the Netherlands (Louwe Kooijmans 1970/1971; Verhart 1995). At the moment the total number of finds is over 500 (Verhart 2004:57). Among them are antler artefacts and palynological data from the 'Eurogeul' locality in the North Sea off the Dutch coast. They postulated that Mesolithic people - whose isolated bones were found at different spots in the Southern Bight of the North Sea - hunted moose, horse and wild boar in this area.

2.4.9. Further investigations indicated that marine as well as terrestrial mammals were present in what is now the Southern Bight of the North Sea between the British Isles and the Netherlands in parts of the Middle and Upper Palaeolithic period from 44,000 to 28,000 BP. This evidence led to the hypothesis that the site was once part of the Rhine-Meuse delta system, and that marine mammals such as pinnipeds and whales could easily enter this large estuary, where their remains were deposited together with carcasses of terrestrial mammals (Glimmerveen *et al*. 2004:51-52).

2.4.10. The so far oldest archaeological finds from the North Sea floor were recovered in 1999. Several Middle Palaeolithic hand axes and flint artefacts were collected together with fossil bones and Mesolithic implements in heaps of debris from shell-fishing off the Dutch coast (Verhart 2004:57-59).

2.5. SETTLEMENT PATTERNS AND ETHNOGRAPHIC ANALOGUES

2.5.1. The dynamic of human interaction with the landscape is central to placing groups within reconstructed palaeogeographies, so that likely activity sites and their consequent archaeological deposits can be judged. Hominin settlement pattern models, which are generally based around determining environmental factors, can be very useful; particularly when baseline information for assessing these areas is primarily geomorphological and environmental. At the same time, attempts are made to recognise the capricious nature of human action and the sociocultural factors that can influence the human relationship with that environment. This involves looking at contemporary cultural behaviour inferred from the archaeological record and modern ethnographic examples of human behaviour in broadly similar environmental and economic circumstances.

2.5.2. The settlement pattern models that correlate human activity with environmental factors can be particularly effective on a regional scale, where they are valuable tools for refining the broad refuge and dispersal models drawn from palaeodemography. For example, Fischer's work suggests that within the Scandinavian region, evidence of the Upper Palaeolithic and Early Mesolithic shows 'the ultimate northern border of human habitat … was probably very diffuse, but tended to keep away from the most recently deglaciated areas, which were generally inhospitable to terrestrial life: plants and reindeer as well as humans' (1996:172). Instead he suggests that 'at the other ultimate border to human habitation – the ocean coast – the situation seems to have been quite different … [and] it must be recommended that the research priority be also given to the study of the coastal border, which may be the source of the most fundamental new insight into the way of life of early humans' (1996:173).

2.5.3. At a local scale of analysis, specifically within aggregate areas, conclusions are less definitive and serve to characterise probable human activity rather than determine occupation of a particular section of a river floodplain. However, the topography and environment of reconstructed areas is often still distinctive enough to be useful. The seasonal migration of Upper Palaeolithic and Mesolithic hunting and foraging groups is well-established; the 'coastal-inland' model of seasonal movements provides a useful template for likely activity (Jacobi 1979; Clutton-Brock and Noe-Nygaard 1990). Rivers were often used as routeways through the landscape as well as exploited for fishing. Valley topography can also provide primary hunting locations, where herds can be channelled through constricting topography and game can be flushed out. Equally, caves are prime, if rarer, locations of activity.

2.5.4. Other resources, occurring at specific locations, also acted as a draw to these groups, including lithic sources and seasonal foods. A number of Early Mesolithic sites, for instance, consist of small scale, short term occupations around former lake edges suggesting groups returning repeatedly to hunt at the same locations for short periods (Bokelman 1980; 1985; Barton *et al.* 1995). The idea of 'small hunting stands or bird hides' are interpreted from evidence of 'miniature living floors, where one or two people sat, prepared flint points, snacked, and perhaps slept on the matting' (Barton *et al.* 1995:112).

2.5.5. The studies which look at the human-landscape dynamic 'have tended to focus on particular aspects of site catchment analysis or on ecological determinants in landuse (e.g. climate, soils, hydrology, vegetation etc.), with little consideration of social factors which might have influenced the choice of habitat or site location' (Barton *et al.* 1995:81). These types of study are the foundation beneath much of the predictive modelling approach to submerged prehistoric landscapes (e.g. Fischer 1996:373-374; Bell and Renouf 2003; Bell *et al.* 2006:16), but, since they are environmentally determined approaches, can be reductive. However, there are problems with these approaches, in particular, the inherent conception of landscape as an objective and static entity.

2.5.6. In order to reincorporate human action and choice into inferences and to further inform hypotheses, examples of sociocultural factors influencing human interaction with the landscape can be drawn from the archaeological record. The notion of a 'persistent place', the repetitive use of a single location, are 'occurrences defined by a conjunction of a particular mode of human behaviour and a fixed point in the landscape' (Barton *et al.* 1995:109; Schlanger 1992). There are, however, far fewer studies addressing sociocultural factors in early prehistoric settlement patterns. Barton suggests 'the range of meanings attached to natural landscape features and their importance in defining social and group identities is indicative of the type of information often ignored by archaeologists because of its apparent invisibility in the material record' (1995:110).

2.5.7. Consequently, modern ethnographic accounts of hunter-gatherer-fisher groups are sometimes used as more accessible analogies. Conclusions about the significance of streams, rivers, pools, drainage basins, and watersheds 'as essential reference points and boundary markers or, more practically in the case of rivers and lakes, as means of travel and communication' are often highlighted (ibid.). More specific patterns of coastal resource exploitation, fishing practices and preferred estuarine sites, are also drawn from modern groups. However, there are complications involved in comparing groups across time and space and it has been suggested that this kind of analogous use of ethnographic examples is equally reductive and inherently 'dubious' (Gosden 1999).

2.5.8. This is particularly pertinent in the case of submerged palaeolandscapes. The dynamism of the landscape during the Upper Palaeolithic and Mesolithic periods would also have influenced human activity. The environmental and topographic baseline would have been changing as sea level rose. In fact, the speed of sea level rise, approximately 30m between 10,000 and 6,000 BP (9,600 and 4,800 cal. BC), and the relatively low gradient landsurfaces would have resulted in rapid rates of submergence of large areas of land. This would have been apparent within individual lifetimes. Within the memory of a social group, the environment would have been shifting coastal zones and highlands, with the relationship between each moving and being remade. There are no comparable ethnographic circumstances or contemporary examples to draw analogies from for the effects of this kind of change. It is therefore preferable to use all of these models carefully as illustrations to inform hypotheses.

2.5.9. Perhaps more significantly, all of these models can only be used in the interpretation of the activity of prehistoric *homo sapiens*. Modern humans did not appear in Northern Europe until the Middle and Upper Palaeolithic transition (their rise was between 40 and 30 ka). Prior to this period our ancestors were in fact a different hominin species for which we are no more of a reasonable analogy than other primates. These hominins had different cognitive processes. Therefore, social action cannot generally be inferred back into the Lower and Middle Palaeolithic periods.

2.5.10. Characterising potential activity and broad patterns of behaviour is central in order to assess potential archaeological deposits. At the same time, understanding the limitations of these models, analogies and sources is equally important. These issues have a particularly potent influence on how the potential archaeological resource is conceived and therefore evaluated, and the scale at which they are applied is therefore crucially important.

2.6. ARTEFACTS AND ARCHAEOLOGICAL DEPOSITS

Transgressions and Regressions – Artefact Survival

2.6.1. Artefact survival in submerged palaeogeographies cannot be directly correlated with terrestrial deposits. There are two factors in particular that make submerged deposits unique. The modification processes involved in multiple episodes of transgression and regression have few terrestrial analogues and it has been suggested that recent studies 'simultaneously over-simplify and under-estimate' the importance of their action on the archaeological record (Dix and Westley 2004:1). The second is the unusual depositional environment of the artefacts in submerged deposits and the consequent potential for the preservation of organic remains.

2.6.2. The idea that marine transgression would simply remove any sedimentary deposits within which archaeological material might be found, scouring back to bedrock in most places, is an easy assumption. The repeated nature of the process would certainly seem to work against the idea of surviving Pleistocene geomorphological features and archaeological deposits. It is possible that any preserved sediments would be those strata that survived the last transgression by virtue of their location in channels, or geomorphological hollows, whilst the majority of sediment across, for example, floodplains would be removed. In some areas this appears to be true, including, for example, parts of the Bristol Channel (Tappin *et al*. 1994:88).

2.6.3. The known surviving archaeological resource is generally located in inshore locations. The best preserved Baltic sites were found in sheltered locations. There is, however, evidence that channels from earlier phases of low sea level do survive.

West *et al.* (1984) have discussed an Ipswichian channel off Selsey Bill. Further evidence for pre-Devensian and pre-Cromerian Complex channels was identified in the Eastern English Channel and the Happisburgh and Pakefield studies as part of this study (see **Volumes V** and **VII**).

2.6.4. The second factor relates to the relative degradation of archaeological deposits in submerged environments and in particular, artefacts made of organic materials, and other organic deposits. These kinds of material are much more likely to survive in waterlogged, anaerobic environments and, therefore, more archaeological information will survive from wooden or bone artefacts to organics of microfossil size. In the Baltic sites 'the incorporation of artifacts [*sic*] into sediments of the seabed ensures that important artifacts and structures of organic material may often be extremely well preserved […] of special note are the conditions for preservation of materials such as textiles, wood, bast, fishbones and encrusted food on pottery (Andersen 1985)' (Smed 1987:117). These kinds of finds yield significant new information about early prehistory, precisely because they are unlikely to survive in the established terrestrial record. In these circumstances marine transgression has been an advantage to artefact survival.

2.6.5. These kinds of unique finds, such as dwelling structures including hide flooring and a boat burial at Mollegabett II, have become part of the common perception of submerged archaeological material (Grøn and Skaarup 1993). However, there is a difference between rubbish deposited into waterlogged sediments and archaeological material deposited in a terrestrial environment which has subsequently become submerged due to changing water levels. An Upper Palaeolithic deposit in a similar coastal position close to the current shoreline would have been subject to approximately 10,000 years of terrestrial conditions prior to its submergence. It is worth recognising that simply because a deposit is now underwater it does not mean it has always provided an anaerobic environment. Earlier material would have been deposited in then-terrestrial locations; these may have included wetland conditions or seasonally waterlogged sites. Surviving Lower and Middle Palaeolithic material in particular would have been subjected to changing post-depositional conditions due to climate change, affecting changes in groundwater and hydrodynamic systems as well as shifts from terrestrial to marine conditions. However, there is potential for the survival of organic deposits and artefacts that would not survive in other, aerobic conditions.

Contexts

2.6.6. Understanding the context of archaeological material is central to determining the nature of the archaeological information that can be drawn from it. Material that has been located *in situ*, that is in the location it was originally deposited in (primary context), is interpreted differently to material material that has moved away from where it was first deposited as a result of subsequent human activity or natural phenomena (secondary context). In the terrestrial record, Upper Palaeolithic and Mesolithic material is more likely to be found in primary contexts, which can include flint scatters, animal processing sites, hearths and living floors.

2.6.7. Due to repeated glacial activity the terrestrial Lower and Middle Palaeolithic record is predominantly comprised of fluvially-derived material from secondary contexts, particularly stone artefacts such as hand axes. Known examples of *in situ* activity or occupation sites are extremely rare. Material in secondary contexts that is subsequently reworked by marine transgression and regression processes would result in their having a 'tertiary' context (Dix and Westley 2004:93).

2.6.8. Aggregate areas are focused on former river systems and their gravel deposits. These areas have potential for both primary and secondary context material, with fine-grain, fluvial sediments preserving any primary sites and the gravels potentially containing derived material. It is worth noting that the gravels themselves represented a useful resource to prehistoric groups and *in situ* material may, therefore, be found on surfaces within those gravels. However, the highest potential for deposits in primary contexts is within the fine-grain infill sediments.

2.6.9. It is the upper, reworked marine sediments that may contain artefacts in tertiary contexts. Many trawled or grab sampled finds appear to come from this source. Consequently, whether finds such as the bone and antler artefacts from Brown Bank (Louwe Kooijmans 1970/1971; **Section 2.4.8**) came from upper marine sediments or the underlying sediments is unknown. Fedje and Josenhans' work in British Columbia retrieved a stone tool from the seabed, which they suggest came from lag deposits of a Late Glacial/Early-Post Glacial fluvial system (Fedje and Josenhans 2000:101). Though given the lack of stratigraphy this may actually be from a tertiary context.

2.6.10. The question of contexts is significant to the way that the material is interpreted. If the context is known, archaeological information can be determined. Material from secondary, and subsequently tertiary, contexts are difficult to interpret because they are viewed as having been removed from their original depositional environment, so that some behavioural information has been lost to physical processes.

2.6.11. Hosfield's work has presented interpretive frameworks for secondary context material and most recently has begun to address site formation processes as tractable problems (2001; 2004). Furthermore, Hosfield suggested that if assemblages are addressed at lower resolution, their removal from their original location becomes far less significant. If questions addressed to this material are on a much larger spatial scale, such as regional comparisons of assemblages (see Gamble 1999), reworking over what might formerly have seemed large distances is relatively inconsequential.

2.6.12. At the same time, there is latent information yet to be drawn from the artefacts themselves, which is not defined by their find context. Hosfield (2004) has also been addressing the physical marks of reworking on artefacts. This is again related to secondary contexts, but suggests that artefacts might be used to assess distances of fluvial transportation by evidence of attrition-related, mechanical fracturing. This approach might be applied equally successfully to tertiary context marine reworked material, although significant research would be required before these effects could begin to be quantified.

2.7. CONCLUSIONS

2.7.1. Regarding the prehistoric potential of aggregate areas of the UK, the model presented by Baltic submerged sites appears to be the exception rather than the rule. To use the

Baltic model uncritically to inform our expectations, evaluation methodology or notions of archaeological potential would be flawed.

2.7.2. There has, in UK archaeology over the last 15 to 20 years, been a distinct emphasis placed on the archaeology of landscapes, resulting in a well-developed body of theoretical, geographical and anthropological literature.

2.7.3. The potential for surviving landsurfaces that might be complete enough to be described as a landscape, from any period earlier than the Mesolithic in the most recently submerged, coastal and protected areas, is limited.

2.7.4. In short, the archaeological resource should not be imagined as a series of primary context sites found in a series of prehistoric horizons within the stratigraphy of the seabed. Rather, work should take into account:

- the truncated and modified nature of the remnant stratigraphic architecture;
- the importance of spatial and temporal resolution to understanding this material;
- the material difference between the potential Lower and Middle Palaeolithic resource and possible Upper Palaeolithic and Mesolithic archaeology. They constitute different timescales, species and characteristic archaeological records divided by the Devensian glaciation.

2.7.5. Nonetheless, so far as managing the effects of marine dredging on the historic environment is concerned, the avoidance of possible primary context sites is the highest priority.

2.7.6. Crucially, this necessarily theoretical discussion of the baseline information highlights the importance of empirical investigations. Initial hypotheses need to be interrogated and a more systematically-acquired dataset, on which to develop further hypotheses, is required.

2.7.7. This discussion demonstrates the difficulties inherent to broad scale predictive modelling of the English Channel and southern North Sea regions in order to prospect for archaeological sites. The variable factors at regional scales are at present still too numerous to produce anything other than a 'speculative survey'. This highlights the value of an area-specific, high resolution, palaeogeographic reconstruction approach at a local scale. This is the approach undertaken during the archaeological evaluation of aggregate areas.

3. OVERVIEW OF THE REPORT VOLUMES

3.1. INTRODUCTION

3.1.1. The present part of this volume aims to give an overview of the report volumes and the general volume structure.

3.2. VOLUME I: INTRODUCTION

3.2.1. This volume informs about the overall project background, its objectives and the adopted methodological approach. Furthermore, it outlines the baseline environment, including the general marine geoarchaeology and its relation to submerged prehistoric landscapes, problems of palaeogeographic reconstructions, the wider archaeological context of prehistoric northern Europe populations and submerged prehistoric archaeology as well as settlement patterns and ethnographic analogues. The preservation of artefacts and the nature of archaeological deposits are discussed before final conclusions are drawn.

3.2.2. The last part of **Volume I** summarises the overall project conclusions.

3.3. VOLUME II: ARUN

3.3.1. This study was commissioned in 2003 by MIRO under the financial support of SAMP financed through Round 1 of ALSF. It was a stand alone project called 'Seabed Prehistory – Gauging the Effects of Marine Aggregate Dredging'. The study area was chosen as a result of prospecting within the Owers Bank aggregate dredging area following consultation with representatives from the marine aggregate industry. The Palaeo-Arun area is located approximately 18km south of Littlehampton, off the coast of West Sussex in the English Channel.

3.3.2. Survey work took place from 1st to 18th July and from 27th to 29th September 2003. Twenty vibrocores, 108 seabed grab samples and 245km of seismic survey data were collected over a 3.5km by 1km area, but primarily in a central 1km² around a buried palaeochannel feature.

3.3.3. The methodological conclusions included:

- Shallow seismic data can provide a sufficient understanding of the subsurface geological structure as to allow features such as palaeochannels to be interpreted and modelled in 3D if the correct seismic source is used. Seismic surveys can help archaeologists to understand the palaeogeography of an area and can be used to guide further work such as vibrocore surveys. However, the seismic data must be collected at an appropriate line spacing depending on the size of the features of interest.

- Bathymetric data, which maps seabed topography, is not an appropriate tool for assessing, identifying or studying submerged prehistoric landsurfaces and their associated archaeological deposits. It provides models of the modern horizon rather than any evidence of relic palaeogeographies or buried stratigraphy. However, it is critical for providing a vertical reference frame for the interpretation of the shallow seismic data.

- Geoarchaeological core loggings and descriptions provide significant additional information to geological logs and photographs. They include sedimentary evidence of the depositional processes involved, as well as descriptions of the sediment types, thus providing environmental data for palaeogeographic reconstruction which enables the assessment of likely human presence.

- Geoarchaeological assessment in offshore circumstances through archaeological access to vibrocores is possible and productive. However, archaeological input into the vibrocore survey locations is considered central to the success of environmental reconstruction and the development of palaeogeographic models.

- Grab sampling survey methodology can be applied for archaeological purposes. The process has retrieved possible artefacts from the upper layers of the seabed. Consequently, it can be an effective tool for indicating the presence of near-surface or eroding archaeological deposits, which would be both significant and fragile, and particularly at further risk from the impacts of dredging. Further work needs to be done to confirm this.

- The trialled grab sampling method could be easily implemented and is complementary to the benthic (marine ecological) survey already undertaken as part of the EIA process.

3.3.4. The palaeogeographic assessment of the study area, using the geophysical and geotechnical data, demonstrated:

- the post-transgressive survival of fine-grain sediments, which could potentially contain archaeological deposits, in offshore locations;

- the dynamism of the geomorphological processes and the size of the sediment regimes at work in this area during the Late Palaeolithic and Mesolithic periods;

- significant evidence of plant migration that appears to relate to the ‘gap’ in the environmental record between northern Europe and southern England providing valuable insight into the environment of early Mesolithic peoples;

- the fact that current terrestrial analogues for stratigraphic formation are not necessarily appropriate to offshore stratigraphy and that there is a consequent need for further research and the development of new geomorphological models.

3.3.5. The study highlighted the importance of the combination of geophysical and geotechnical sources for palaeogeographic evaluation. Geophysical models informed the strategy for environmental sampling and analysis, and the results could be used to refine the geophysical models. Integrated use of these sources was central to the development of more reliable palaeogeographic characterisations. Furthermore, this work demonstrated how these palaeogeographies could be reconstructed, and how they may have been inhabited, and thus provided a more supportable assessment of the potential for archaeological impacts to arise from aggregate extraction.

3.3.6. Radiocarbon dating confirmed a late Devensian to early Holocene date for the pollen sequences analysed from the cores. These dates were in accordance with the recorded vegetational sequences.

3.3.7. Significant further research potential was recognised in the survey dataset, and as a result of the project conclusions. This potential included:

- The analysis suggested that the environmental data have significant further potential for studying the palaeovegetation of southern Britain during the early Holocene with special reference to floral migration from glacial refugia and to the habitat of early Mesolithic communities. There would also be considerable value in comparing this information with other offshore, English palaeochannel sequences from the Sussex Ouse and Sandown Bay area adjacent to the Isle of Wight.

- The project's geophysical dataset was large and of high quality and there was scope for further geophysical processing of the data to allow interpretation of smaller features. There is an apparently older, lower palaeochannel feature, which could be pursued through additional survey lines.

- Additional fieldwork would also be valuable to further interpretation. Deeper cores would clarify features at the base of the palaeochannel, and it would be beneficial to try and establish the point at which the identified episodes of sedimentation began. Many of the potential features indicated by the geophysics, including the base of the palaeochannel being studied and the earlier, deeper, palaeochannel were beyond the reach of vibrocores.

3.3.8. An active engagement with the developing study of prehistoric submerged deposits and its related management issues was integral to the 'Seabed Prehistory' Round 1 project. This involved a formal and informal consultation process with the Project Steering Group, individual researchers in related Quaternary archaeological and science fields and researchers working on other methodologically-focused ALSF funded projects. Both the project methodology and conclusions have been presented to a wider audience of people from industry and regulatory bodies as well as members of the research community through a series of conference and seminar papers, public talks and posters. This process continued with the circulation of a first Draft Technical Advice Note for industry. Meanwhile, the second and updated version has been submitted, and the publication of project conclusions in academic journals is being prepared.

3.4. Volume III: Arun Additional Grabbing

3.4.1. The Arun Additional Grabbing project comprised part of the ALSF Round 2 'Seabed Prehistory' project administered by EH, and started in April 2005. Its intention was to further investigate the relationship between struck flint and palaeogeographic features in the Palaeo-Arun area recovered in the 'Seabed Prehistory' Round 1 project in order to further inform mitigation strategies for aggregate license applications. This was accomplished by conducting a grab sampling survey that took place between 26th March and 9th June 2005 adjacent to the Owers Bank licensed dredging area *c.* 18km offshore Littlehampton, West Sussex, in the English Channel. The grab samples were processed during August 2005.

3.4.2. The results and conclusions of the grab sampling survey can be summarised as follows:

- Possible struck flint was recovered which does not appear to correlate spatially with palaeogeographic features;

- Large quantities of peat were recovered suggesting that deposits relating to the Palaeo-Arun valley are exposed on the seabed;

- Charcoal was recovered from one of the blocks of peat. This has been radiocarbon dated to the Early Mesolithic period and is a possible indication of human occupation in the area at this time; a piece of reed (*phragmites* sp.) was also dated to the Early Mesolithic period.

- The methodology proved to be supportive in assessing and evaluating prehistoric seabed deposits.

3.5. VOLUME IV: GREAT YARMOUTH

3.5.1. The Great Yarmouth study was commissioned in March 2005 by English Heritage as part of the ALSF Round 2 project 'Seabed Prehistory'. Great Yarmouth was selected for study as it represented an aggregate dredging area with a different geological setting, and as such archaeological potential, to the previously studied Paleo-Arun area. Surveying the dredging area off Great Yarmouth aided in the understanding of the varying archaeological contexts in which aggregates are found.

3.5.2. The study area for this study was chosen as a result of prospective survey lines and in conjunction with representatives from the marine aggregate industry. The study area comprised an approximate 800 x 800m grid situated in the south-western corner of dredging area 254, approximately 10km to the east of Great Yarmouth.

3.5.3. The geophysical survey involved the acquisition of single beam echosounder, sub-bottom profiler (surface-tow boomer and pinger sources) and sidescan sonar data. The results of these are summarized below:

- A digital elevation model of the bathymetry within the study area was produced using single beam echosounder data. This highlighted a southeast–northwest orientated mound.

- The sub-bottom profiler data indicated a coarse sand and gravel unit observed throughout the study area, overlain by an intermittent unit of fine-grained sediments which may contain peat. These units were in turn overlain by a thin layer (<1m thick) of recent gravely sands. This was confirmed on the sidescan sonar data.

3.5.4. Based on the geophysical data interpretation vibrocore locations were proposed within the area. Seventeen vibrocores were acquired at eight locations within the study area. The aims of the vibrocore survey were to calibrate the geophysical data with regards to stratigraphy; to help provide a relative chronology for the area identifying the relationship between palaeogeographic features; to provide an absolute timescale of the depositional processes through appropriate dating techniques; and to provide evidence for the environmental reconstruction of the depositional environments. Four sedimentary units were identified within the vibrocores correlating to those identified within the geophysical survey. Samples were assessed and analysesd for their pollen, diatom, foraminiferal, ostracod, waterlogged plant and molluscan content. Radiocarbon (^{14}C) and optically stimulated luminescence (OSL) dating were carried out on selected samples. The results of the sedimentological, environmental and chronological data and their interpretation are summarised below:

- **Unit 1** comprising gravels and sands interpreted as part of the shallow marine Yarmouth Roads formation probably deposited during the Cromerian Complex period (OIS 13);

- **Unit 2** comprising silts sands and gravels interpreted as forming fluvial environments with OSL dates suggesting deposition during the Wolstonian (OIS 8, 7 and 6) period. Charcoal from this unit is a possible indication of human habitation at this location, or could be the result of natural processes;

- **Unit 3** comprising sands, silts and clays indicative of sea level rise, climate amelioration, freshwater and estuarine environments with OSL dates and palaeoenvironmental data suggesting deposition during the Ipswichian (OIS 5e) period, although radiocarbon dates suggest a potentially later deposition date. Charcoal from this unit is a possible indication of human habitation at this location, or could be the result of natural processes. Sub-aerial exposure of this unit is also a clear indication of the survival of terrestrial deposits in this area;

- **Unit 4** comprising gravel and sands is indicative of more recent (Holocene) seabed sediments.

3.5.5. In terms of archaeological significance, the charcoal recovered from the vibrocores may have been caused by natural forces e.g. lightning, although may equally be the result of deliberate anthropogenic burning. One piece from **Unit 3** was radiocarbon dated to 49,500±3,000 BP (NZA-27095). This is at the limit of radiocarbon dating and the position of this sample between two OSL samples dating to 175.7±22.6 ka and 116.7±11.2 ka would suggest the charcoal dates from the Ipswichian (OIS5e) period. This would also be the case for the charcoal found higher up the profile in the same unit. If these pieces are evidence of habitation from Ipswichian deposits this would be highly significant as this period is at present thought to be one of non-occupation of the British Isles.

3.5.6. The charcoal further down the sequence at **Unit 2** may date from an archaeological period which is significantly earlier. Its proximity to the OSL sample at 31.37m below OD dating to 577.2±65.4 ka may be suggestive of occupation of this area during the Cromerian Complex period or later. This unit, comprising fluvial sands and gravels, may contain reworked Palaeolithic material as Pleistocene fluvial deposits onshore have been proven to be implementiferous.

3.6. VOLUME V: EASTERN ENGLISH CHANNEL

3.6.1. In October 2004, WA was commissioned by MIRO to undertake the research project ‘Seabed Prehistory Round 2 – Gauging the effects of marine aggregate dredging’ under the financial support of the Sustainable Land Won and Marine Dredged Aggregate Minerals Programme (SAMP). This project extended the methodology of the ‘Seabed Prehistory’ Round 1 project into two additional aggregate dredging zones, namely Eastern English Channel and the Humber (**Section 3.7**).

3.6.2. In Round 2 year 2 the project focussed on the Eastern English Channel dredging zone. The study area (36km^2) lies approximately 30km offshore south-west of Beachy Head, West Sussex, between the licensed aggregate areas 464 West and 464 East.

3.6.3. The analysis of the general pattern of prehistoric occupation of southern Britain and northern France showed that this part of Europe was inhabited since the Lower

Palaeolithic period. The distribution of the sites on the two coastlines suggested a link between the two areas. The number of archaeological sites on the coasts of southern Britain and northern France dating from the Lower Palaeolithic to the Mesolithic also suggested that, during times of lower sea levels, there was probably exploitation, and possibly inhabitation, of exposed land between the current coast lines defining the English Channel. The presence of palaeochannels within the study area is significant as much of the recovered prehistoric archaeological material, particularly in northern France, has been found within river valley deposits. These French rivers are known to have offshore extensions.

3.6.4. The survey methodologies comprised bathymetric, sidescan sonar and shallow seismic surveys as well as vibrocoring and grab sampling. All survey operations were conducted aboard the *MV Ocean Seeker* between 14th and 24th September 2005 by Gardline Environmental Ltd under the supervision of WA staff. A high quality dataset was acquired including approximately 498 line kilometres of geophysical data, 16 vibrocores and 100 grab samples.

3.6.5. The sediments observed within the geophysical and geotechnical data potentially contain prehistoric material. OSL dating suggests that the earliest *in situ* archaeology in the survey area would date from the Middle Palaeolithic although derived artefacts from the Lower Palaeolithic could be present. Gravel deposits within this early sequence are possibly of fluvial origin. They may represent river terraces and could therefore contain similar material recovered from terrace deposits on land.

3.6.6. There is the potential for the survival of prehistoric remains within or at the surface of the oldest identified unit (OIS 6/5e). This unit contains evidence of sub-aerial exposure and is located on the edge of the main valley. The indicatively terrestrial part of this deposit has survived *in situ*. Five other units comprise finer grained deposits, possibly from a floodplain environment. These types of landscapes and environments are obvious places for the survival of *in situ* archaeological remains.

3.6.7. Within the valley itself areas of terrestrial environments are inferred. The base of one unit marks a period of fluvial incision when large parts of the palaeovalley feature including the surface of another unit might have been exposed as land surfaces. Two channel infill units form part of a terrestrial environment when surrounding areas of the main valley feature were exposed.

3.6.8. The environmental history of the area during the Late Upper Palaeolithic and Mesolithic period are easier to elucidate from the data. If relative pollen dating is correct, one unit was deposited during the Godwin zone II, *c.* 12,900 to 11,600 BP (13,200 to 11,400 cal. BC), corresponding to the late Upper Palaeolithic period. Pollen and ostracod assessments point towards slow moving freshwater environments for this period within the wider context of a river valley.

3.6.9. The sedimentary record aided by radiocarbon analysis suggests that the three youngest units were deposited during the Early Mesolithic period. They indicate that braided channels within a wide valley are submerged by sea level rise around 8,500 BP (7,500 cal. BC). Thick sequences are preserved which probably include fluvial and estuarine alluvial sedimentation relating to the Early Mesolithic period.

3.6.10. These fluvial, estuarine and coastal environments are potential places where both *in situ* and derived archaeological material may survive.

3.6.11. The finds from the grab samples are of geological and modern origin. No prehistoric archaeological material was recovered. The deposit from which the samples derive is analogous to the youngest unit described in this report, radiocarbon dated to the early Mesolithic period. As mentioned above, it is likely that the deposit rapidly accumulated as a result of rising sea level during the early Mesolithic period. Any prehistoric material within this deposit is likely to have been reworked from its original context. The sieved grab samples represent a very small fraction of the total deposit within the grab study area and as such a lack of prehistoric archaeological material within the samples does not mean that it does not exist within this deposit.

3.6.12. This study demonstrated the survival of Middle and Upper Palaeolithic as well as Early Mesolithic landscapes that were exploitable by early humans within the Eastern English Channel area. This phase of the project further informed the development of archaeological assessment and evaluation strategies for marine aggregate extraction.

3.7. VOLUME VI: HUMBER

3.7.1. In October 2004, WA was commissioned by MIRO to undertake the research project 'Seabed Prehistory Round 2 – Gauging the effects of marine aggregate dredging' under the financial support of the Sustainable Land Won and Marine Dredged Aggregate Minerals Programme (SAMP). This project extended the methodology of the 'Seabed Prehistory' Round 1 project into two additional aggregate dredging zones, namely Eastern English Channel (**Section 3.6**) and the Humber.

3.7.2. The Humber area was selected for study as it represented an aggregate dredging area with different geological setting, and as such archaeological potential, to the previously studied areas. The study area of 6km x 1.2km lies to the south of the Humber Estuary and is situated between and partly within two dredging areas approximately 16km off the coast of Lincolnshire. The study area was chosen as a result of prospective survey lines and as being representative of the general geology of the area.

3.7.3. The geophysical survey methodology comprised a bathymetric survey to establish water depths and seabed morphology across the study area, a sidescan sonar survey to record the seabed sediments and further highlight the seabed morphology and a shallow seismic survey to identify individual sub-seabed horizons that were then modelled.

3.7.4. Based on the geophysical data interpretation vibrocore locations were proposed within the area. The aims of the vibrocore survey were to calibrate the geophysical data with regard to stratigraphy, to help provide a relative chronology for the area, i.e. to identify the relationship between palaeogeographic features, to provide an absolute timescale of the depositional processes through appropriate dating techniques, and to provide evidence for the environmental reconstruction of the depositional environments.

3.7.5. A grab sampling survey was also undertaken in order to locate any exposed fine grained deposits and/or prehistoric remains within the upper sediment layers of the seabed.

3.7.6. The geophysical and vibrocore data showed a sedimentary sequence dating from the Devensian glaciation. The data showed deposition of fluvioglacial sediments deposited as the ice sheet retreated and subsequent reworking and deposition of shallow marine/sublittoral sediments associated with the continuing inundation/marine transgression during the late Mesolithic period.

3.7.7. OSL and radiocarbon dates were taken from vibrocore samples. Although a number of dates came out reversed they were considered to be reliable on the millennial scale as shallow marine deposits at *c*. 20m below OD in the North Sea would be expected to date to the late Mesolithic period. The fact that the dates are reversed is most likely due to reworking of the sediments in a shallow marine context. The dates do however confirm that this reworking has probably occurred during or slightly after the late Mesolithic period.

3.7.8. Potential for *in situ* prehistoric archaeological remains in this area is low. This is due to the deposits either being glacial or shallow marine in origin. There is however potential for reworked Palaeolithic and Mesolithic archaeological material to be present within marine aggregate deposits. If this material exists it is likely to be reworked into the shallow marine and glaciofluvial sands and gravels identified within the area. No artefacts of prehistoric origin were recovered from the grab samples or vibrocores; however these represented a very small percentage of the area surveyed.

3.7.9. The methodology of combining geophysical and geotechnical surveys proved successful in assessing the archaeological potential of this study area. Furthermore, an assessment of the effect of line-spacing on the interpretation was carried out during the interpretation phase of the project. It was shown that although using 25 x 100m grid line spacing would improve the resolution of the interpretation, all features observed on the smaller grid were observed on the 50 x 100m grid as well. As such, it was considered that a 50 x 100m grid was suitable for identifying submerged landscapes.

3.8. VOLUME VII: HAPPISBURGH AND PAKEFIELD

3.8.1. In 2005 WA was commissioned by EH to undertake a geophysical survey to trace the Ancaster and Bytham palaeoriver systems offshore of locations at Happisburgh, Norfolk and Pakefield, Suffolk. This project has been funded through the Aggregate Levy Sustainability Fund (ALSF) and was additional to the 'Seabed Prehistory' project.

3.8.2. This project was inspired by the current research on the palaeoriver systems in East Anglia which extend into the southern North Sea basin. The archaeological potential of these systems has been established on land but as yet their offshore potential had not been assessed.

3.8.3. The principal objectives of the Happisburgh and Pakefield Exposures project were to trace sediments of known archaeological potential onshore into the offshore marine environment. The fine-grained sediments onshore are unique and have changed our understanding of the earliest occupation of Britain. Finds within these sediments have demonstrated that human occupation of north-west Europe was earlier than hitherto thought, *c.* 700,000 year ago. The survival of these deposits at the base of the cliffs at Happisburgh and Pakefield is unexpected considering their character and nature, and the series of geomorphological processes that have affected them. As these deposits reside at the base of the cliffline and on the foreshore there is a possibility for their survival offshore. If traced, this would allow the geophysical signatures of fine-grained deposits to be assessed and improve methodologies to effectively survey these deposits in the future.

3.8.4. In order to achieve the project objectives a geophysical survey was undertaken. WA carried out the geophysical survey at sites off the coast of Suffolk and Norfolk aboard the R/V *Wessex Explorer* between the 1st and 6th June 2006.

3.8.5. Based on preliminary interpretations of the Pakefield and Happisburgh geophysical data, a further variation to the project was developed. This involved a vibrocore survey at three locations identified from the geophysical data at the Pakefield site. The vibrocoring was undertaken by Gardline Surveys on the 19th July 2006, from the S/V *Flatholm*. The aim of the geotechnical survey was to confirm the geophysical interpretation, and to provide environmental samples for assessment and analysis.

3.8.6. A high quality dataset was acquired and the results show a sedimentary sequence pre-dating the Anglian glaciation, overlain by Holocene sands.

3.8.7. At Pakefield, sediment units were observed on the geophysical data that matched the extent and form of those described at the base of the cliff exposures (Parfitt *et al.* 2005). Vibrocore analysis and environmental assessments and analyses enhanced the geophysical data interpretation and enabled a better understanding of the sediments depositional environments. This facilitated correlation between onshore and offshore sediments. Although sediments of the Cromer Forest-bed Formation no longer exist offshore within the study area, older sediments interpreted as the Wroxham Crag Formation were identified. It was within the upper part of the Wroxham Crag Formation that worked flint was found onshore. The survey at Pakefield successfully demonstrated that sediment units identified onshore can be traced offshore and that not all of these very early terrestrial sediments that are now in submerged areas have been removed by glacial processes and/or marine erosion.

3.8.8. At Happisburgh, the survey was carried out further from the coast in deeper water to that of Pakefield due to the presence of beach groynes that posed a risk to the equipment. Only sediments interpreted as older than those identified in the cliff exposures and on the foreshore were identified on the geophysical data. However, it is possible that younger sediments relating to the Cromer Forest-bed Formation observed on the foreshore and related early Middle Pleistocene sediments may be preserved closer to the shoreline.

3.8.9. The Happisburgh and Pakefield Exposures Project has demonstrated that fine-grained deposits can be identified and surveyed by use of geophysical and geotechnical methodologies in nearshore areas, even where deposits are close to the seabed. The results of the project will directly inform future marine aggregate dredging, both in terms of baseline knowledge of the historic environment in aggregate dredging areas, and the methodologies that can be used by industry to assess and mitigate any significant effects of dredging.

3.9. VOLUME VIII: PROJECT SYNTHESIS

3.9.1. In 2005, WA was commissioned by EH to compile a comparative analysis of all ALSF Round 1 and Round 2 'Seabed Prehistory - Gauging the Effects of Marine Aggregate Dredging' project studies. The project synthesis sets out the project's results and conclusions in terms of methodological and geoarchaeological objectives.

3.9.2. The comparative analysis of the survey methodologies comprises three separate discussions:

- The fieldwork implementation and data quality of the geophysical survey are compared between areas and the merits of the different geophysical processing and interpretation techniques are evaluated;
- The merits of the vibrocore methodology are evaluated between the areas, in terms of the scale of palaeogeographic features and the calibration of the geophysical data related to the number of vibrocores taken. The depth of penetration of the cores is assessed compared to feature depth, and alternative coring options are explored;
- The data from the grab sampling surveys are compared to test the association between the presence of prehistoric artefacts on the seabed and palaeogeographic features.

3.9.3. The comparative analysis of the geoarchaeological results comprises – in a chronological order – discussions on the extent and character of the prehistoric seabed deposits of each area in terms of their sediment architecture and the interpretations of the depositional processes that formed this architecture. From this comparison comments are made on the archaeological potential of each area and the relative importance of the palaeogeographic features and interpreted landscapes.

3.9.4. The project improved archaeologists and developers understanding of the varying archaeological contexts in which aggregates are found. It developed geophysical and geotechnical survey methodologies for the assessment of prehistoric archaeology within proposed aggregate dredging areas, and contributed to research into prehistoric archaeology. It reduced the impacts of dredging activities on the marine cultural resource by enabling the compilation of better-informed Environmental Assessments in the course of aggregate licensing.

4. OVERALL PROJECT CONCLUSIONS

4.1. INTRODUCTION

4.1.1. The 'Seabed Prehistory' project focused on the small scale and high resolution analysis of five different study areas in the North Sea (Humber, Great Yarmouth, Happisburgh and Pakefield) and the English Channel (Arun, Eastern English Channel).

4.1.2. The outcome of the surveys resulted in the specific aims and objectives of the 'Seabed Prehistory' project, as outlined in **Section 1.4**, being fully met and successfully achieved.

4.1.3. Both the project methodology and conclusions have been presented to a wider audience through a series of conference and seminar papers and posters. These have included industry and regulators as well as the research community.

4.1.4. The comparative methodological assessment highlighted the importance of the combination of geophysical and geotechnical sources for palaeogeographic evaluation. Geophysical models informed the strategy for environmental sampling and analysis, and the results could be used to refine the geophysical models. Integrated use of these sources was central to the development of more reliable palaeogeographic characterisations. Furthermore, this work demonstrated how these palaeogeographies could be reconstructed, and how they may have been inhabited, and thus provided a more supportable assessment of the potential for archaeological impacts to arise from aggregate extraction. These conclusions are discussed in detail below.

4.2. SURVEY METHODOLOGY CONCLUSIONS

Geophysical Surveys

4.2.1. Geophysical survey methodologies were assessed at each study area for evaluating prehistoric seabed deposits. Survey design, acquisition and recording methods were evaluated and developed taking into consideration industry standards and methods.

4.2.2. At each of the five geophysical survey areas, the survey design, both line specification and choice of area, was dependent on the scale of the features to be resolved. Based on the results of the 'Seabed Prehistory' project it was found that surveys undertaken with a line spacing of no more than 100m with crosslines situated up to twice the principle line spacing provided a quality dataset for interpretation. This spacing should ensure the determination of features greater than 100m, depending on their orientation. While a smaller grid such as 50 x 50m would improve the resolution and therefore clarity of geoarchaeological interpretation, this may not be regarded as cost-effective.

4.2.3. Accurate positioning of the vessel and equipment is an essential requirement for a survey. The repeatability of position information is crucial for the corroboration of geophysical data with the geotechnical data, and for the implementation of archaeological mitigation measures.

4.2.4. Bathymetry data were collected during each survey. Bathymetric data not only provides information on water depth and the morphology of the seabed, but also provides a vertical reference datum that can be used to accurately position geophysical horizons from shallow seismic data. Knowing the absolute level of horizons is the first stage in establishing the general chronological context of archaeological features. Throughout the surveys bathymetric data were successfully acquired using a single-beam echosounder.

4.2.5. Sub-bottom profilers are used to investigate the sub-surface geology. In order to establish the most appropriate seismic source to identify sedimentary horizons sub-seabed, numerous seismic sources were trialled during the project. On the basis of this project, the boomer system was shown to produce the best compromise between penetration in the seabed geology and the resolution of geological horizons. Alternative systems, such as pinger and chirp, achieved better resolution of fine-grained (silt and clay) deposits specifically within the first five metres of the seabed, but did not achieve sufficient penetration in the coarse-grained (sand and gravel) deposits targeted for aggregate dredging. As such, it is considered that the boomer is the most versatile source for archaeological purposes.

4.2.6. Digital acquisition of the geophysical data (sidescan sonar and sub-bottom profiler) allowed post-survey processing with gain and filter settings optimised to enable in-depth geophysical interpretation.

4.2.7. Digital dual-frequency sidescan sonar systems are already widely used in the marine aggregate industry and are successful in producing data for archaeological purposes. This was confirmed by the surveys conducted as part of this project. The range setting, dependent on the survey line spacing, needs to ensure full coverage of the survey area, with 200% seabed coverage recommended.

4.2.8. To ensure data quality, surveying operations should be suspended if the effect of the sea conditions compromises the data quality either due to noise effects on the data or excessive instability of the towfish.

4.2.9. The interpretation of the geophysical data illustrated their usefulness as a tool for conducting the initial palaeogeographic evaluation of an area. Although important palaeosurfaces can be identified on the geophysical data, in order to fully reconstruct the palaeogeographic model of the area ground-truthing of the geophysics data is required in the form of vibrocores, grab sampling and subsequent environmental and dating analyses of these data.

Vibrocoring

4.2.10. Based on the initial geophysical data interpretation a judgement-led sampling strategy was developed. A position and recovery depth based upon the geophysical data was generated in order to investigate key stratigraphic sequences.

4.2.11. On the basis of the sedimentary unit descriptions and the comparison of the core logs, major sedimentary units were ascribed principal phases which were then correlated with the sedimentary units described within the seismic interpretation. Profiles created by the phasing were integrated with the seismic data enabling comments on their palaeoenvironmental and geoarchaeological significance to be made.

4.2.12. Geoarchaeological core log descriptions, sampling of the cores and analysis of pollen, diatoms, ostracods, foraminifera, molluscs and waterlogged plants within the sediment, as well as dating appropriate samples, helped define prehistoric seabed deposits and identified any relationships between them. ^{14}C (radiocarbon) and OSL (optically stimulated luminescence) samples were taken from relevant deposits in order to provide chronological information.

4.2.13. During the 'Seabed Prehistory' project the vibrocore survey data provided: calibration of the geophysical data; a relative chronology for the area identifying the relationship between palaeogeographical features; a measure of the absolute timescales involved in the depositional processes (through OSL and ^{14}C dating of appropriate samples); evidence for the environmental reconstruction of the depositional environments; evidence of marine transgression.

Grab Sampling

4.2.14. Grab sampling surveys have been conducted in the Arun, Eastern English Channel and Humber study areas. These have demonstrated that grab sampling survey methodology can be applied for archaeological purposes. The Arun grabbing survey specifically has retrieved possible artefacts and possibly anthropogenic charcoal from the upper layers of the seabed.

4.2.15. Apart from possible artefact retrieval the other advantage of grab sampling surveys lies in the possibility to establish a record of the upper and exposed seabed sediments, which are particularly at risk from the impacts of dredging. These sediments cannot be documented by geophysical analyses, because sub-bottom profiling techniques are not able to record the upper decimetres of the seabed, and sidescan sonar surveys only provide an indication of the surface sediment type. Vibrocore locations will be based on the results of the sub-bottom profiler survey, thus targeting *buried* fine-grained and organic layers. The difference in sediments recordable by grab sampling on one hand and vibrocoring and geophysics on the other hand was verified by radiocarbon dates for the Arun study area which confirmed the difference in age and the presence of a clear stratigraphic sequence.

4.2.16. No evidence of surviving prehistoric deposits was recovered from the Eastern English Channel or the Humber grab samples. However, the sieved grab samples represent a very small fraction of the total deposits within the study areas and as such a lack of prehistoric archaeological material within the samples does not mean that it does not exist within the areas surveyed.

4.2.17. For a better understanding of the results of underwater grab sampling surveys, an assessment of similarities between terrestrial sampling techniques and the grab sampling methodology undertaken as part of the 'Seabed Prehistory' project has been made. Appropriate marine site examples have been included in the discussion. Issues that need to be considered to execute successful grab sampling surveys are: site size, character and condition. These will impact upon the survey design, specifically the size of the area to be sampled, the grid density and the sample size.

4.2.18. In order to ensure an adequate coverage of the area to be investigated by grab sampling, it is recommended to enlarge the sampling scale in terms of study area, grid density and sample size.

4.2.19. With regard to sample size, one approach would be to apply archaeological analysis to the one ton grab samples that are taken within aggregate dredging areas for grain size and sediment/clast analyses. A scan of the sediment could be conducted onboard the vessel, making big scale laboratory processing redundant. By investigating an estimated number of ten samples per day, the amount of sampled sediment could be considerably increased compared to Hamon grab samples, thus increasing the chances to discover archaeological material of any kind. The practicalities of this suggested methodology would have to be investigated to enable the aims of both archaeologists and industry to be satisfied.

4.2.20. With regard to maritime contexts, it would be neither productive nor cost effective to imply an overall high sampling fraction without taking into consideration specific site conditions. The palaeogeographic reconstruction of a study area would have to be balanced against appropriate predictive site models before the application of an especially dense sampling grid would be justifiable and most probably prove successful.

4.2.21. The size of the grab sampling survey area would have to be determined according to the specific site circumstances and the scale of the palaeolandscape features to be investigated. However, the informative results of the Arun Additional Grabbing survey showed that the size should be related to the wider palaeogeographic features in the region.

4.3. The Extent and Character of Prehistoric Seabed Deposits

4.3.1. At any location in the North Sea and English Channel, reworked material from the Palaeolithic and Mesolithic may be present. Those sediments identified during this project as containing, or potentially containing significant prehistoric archaeological material are summarised below. As the earliest known occupation of north-west Europe is presently thought to have begun *c.* 700 ka (Parfitt *et al*. 2006), only deposits identified as this age or later are discussed as having archaeological potential.

- The Arun survey area is dominated by a valley containing fluvial sands and gravels probably dating to the Devensian (OIS 5d to 2) periods. These deposits may contain Upper Palaeolithic and Mesolithic archaeological remains. Above this level, Holocene peats, silts and clays dating to the early Mesolithic period were recovered.

- Oak (*Quercus* sp.) heartwood charcoal recovered by grab sampling stratified within a peat deposit is a dated potential indication of human habitation in the Arun area during the early Mesolithic. The *phragmites* in the peat and the charcoal is dated to c. 8,200 cal. BC (Early Mesolithic). The charcoal could have been formed by natural causes although it is considered more likely to have been produced as a result of deliberate burning. This peat is presently exposed on the seabed. Other, earlier Mesolithic peat deposits were identified by geotechnical and geophysical survey and these may also contain archaeological material.

- Estuarine silts and clays dating to the early Mesolithic deposited at a similar time to the peats were extensive at the Arun site. These sediments, whilst containing a wealth of environmental material, are also known to preserve ephemeral archaeological remains such as human footprints. These types of deposits can also seal and preserve archaeological material.

- Possible flint chips were recovered from the marine “lag” deposit covering the site although these were mostly indistinguishable from flint chips produced by mechanical fracture.

- The Eastern English Channel study area would have formed part of the same channel river system of which the Arun palaeovalley was a tributary. OSL dates and sedimentary data suggest that a marine lag deposit dating to the Wolstonian (OIS 7, 6) or Ipswichian (OIS 5e) is the earliest deposit on the site. This deposit also shows evidence of sub-aerial exposure which dating suggests probably occurred during the late middle Palaeolithic, Devensian (?OIS 5b) period. The deposit itself may contain reworked Palaeolithic material, however, as a landsurface *in situ* archaeological material may be present on it.

- A large palaeovalley cut into this deposit showed evidence of deposition from the (Devensian OIS 2) to the Holocene (OIS 1) early Mesolithic period. One small remnant palaeovalley predating this (OIS 5e to OIS 2) filled with a ?fluvial gravel deposit may contain derived or *in situ* Palaeolithic material. Within the main large palaeovalley a sequence of cut and filled channel sediments were identified by geophysical survey. Sediments towards the top of the sequence contained environmental remains relating to slow moving freshwater and estuarine rivers in this area during the Upper Palaeolithic and Early Mesolithic periods. Freshwater is an essential resource and the identification of these types of freshwater deposits could indicate potential areas suitable for habitation (and potential deposition of *in situ* remains). No artefactual evidence of prehistoric archaeological interest was found in the Eastern English Channel area. However, this is not to say that it does not exist.

- The Happisburgh and Pakefield areas contained two major sedimentary units inferred from the geophysical, geotechnical and environmental data to be recent seabed sediments and sediments predating the earliest occupation of north-west Europe. The archaeological potential of the areas is therefore low although the potential presence of reworked material in the recent sediments is noted.

- The Great Yarmouth area presents probably the most complete chronological and sedimentary sequence of any of the survey areas. However, the dating of this area is complicated. The earliest deposition in the area is shallow marine sands and gravels dated by OSL dating to the Cromerian Complex period (OIS 16-14). These deposits are noted to be within the range of human occupation of Britain.

- Above these shallow marine sands and gravels, freshwater gravels, sand and silt dating from the Wolstonian (OIS 9, 8, 7 and 6) to Ipswichian (OIS 5e) periods contained charcoal which is a possible indication of occupation of the area. Charcoal can be formed by natural causes (e.g. lightning) or may be a direct indication of habitation if it is the result of material burnt as fuel in hearths. If this is indeed evidence of occupation and if the OSL dating is correct then this would be highly significant, as this period is currently thought to be one of non-occupation in the British Isles.

- Above this level estuarine silts and clays deposited during the Ipswichian (OIS 5e) show evidence of subsequent exposure as a land surface (gleying and roots). OSL dating suggests this occurred during the Devensian (OIS 2) corresponding to the late Upper Palaeolithic. This deposit is in areas exposed on the seabed.

- The Humber area contained glacial deposits dating to the Devensian (OIS 2) and marine sands and gravels dating to the Holocene sea level rise (late Mesolithic). The possibility of reworked artefacts in these deposits is noted although unproven in this study.

4.4. Gauging the Effects of Marine Aggregate Dredging

4.4.1. Extraction of gravel and sand by marine aggregate dredging will affect any prehistoric archaeological remains which occur within them. Pleistocene sands and gravels deposited by marine and particularly fluvial processes are both potential aggregate and archaeological resources. Supplying demand for marine aggregates will increasingly remove Pleistocene sediments from the seabed and any related archaeology. An effect of this, in conjunction with associated archaeological study of aggregate extraction areas, should be to provide industry, archaeologists and the public with a greater understanding of our origins.

5. REFERENCES

AHOB 2006: Ancient Human Occupation of Britain 1 project, *Printable Summary Chart* (see Online-Resources).

Allen, M.J., 2000, 'Soils, pollen and lots of snails' in Green. M. (ed.), *A landscape revealed: 10,000 years on a chalkland farm*. Stroud: Tempus. 36-49.

Andersen, S.H., 1985, 'Tybrind Vig: A preliminary Report on a submerged Ertebølle Settlement on the West Coast of Fyn', *Journal of Danish Archaeology* 4:52-69.

Ashton, N., 1983, 'Spatial patterning in the Middle-Upper Palaeolithic transition', *World Archaeology* 15(2):224-235.

Ashton, N. and Lewis, S., 2002, 'Deserted Britain: Declining populations in the British Late Middle Pleistocene', *Antiquity* 76:388-396.

Barton, R.N.E., 1997, *Stone Age Britain*, London: Batsford and English Heritage.

Barton, N., 2005, *Ice Age Britain*, London: Batsford and English Heritage.

Barton, R.N.E., Berridge, P.J., Walker, M.J.C. and Bevins, R.E., 1995, 'Persistent Places in the Mesolithic Landscape: an Example from the Black Mountain Uplands of South Wales', *Proceedings of the Prehistoric Society* 61:81-116.

Bell, M., Caselsine, A. and Neumann, H., 2000, *Prehistoric Intertidal Archaeology in the Welsh Severn Estuary*, CBA Research Report 120, York: CBA.

Bell, T. and Renouf, M.A.P., 2003, 'Prehistoric cultures, reconstructed coasts: Maritime Archaic Indian site distribution in Newfoundland', *World Archaeology* 35(3):350-370.

Bell, T., O'Sullivan, A. and Quinn, R., 2006, 'Discovering ancient landscapes under the sea', *Archaeology Ireland* 20(2):12-17.

Bellamy, A. G., 1998, 'The UK marine sand and gravel dredging industry: an application of Quaternary geology' in Latham, J.-P. (ed.), *Advances in Aggregates and Armourstone Evaluation.* London: Geological Society, Engineering Special Publication 13:33-45.

Blackwell P.G. and Buck C. E., 2003, 'The Late Glacial human reoccupation of north-western Europe: new approaches to space-time modelling', *Antiquity* 77(296):232-241.

Bocquet–Appel, J.P. and Demars, P.Y., 2000, 'Population Kinetics in the Upper Palaeolithic in Western Europe', *Journal of Archaeological Science* 27(7):551-570.

Bridgland, D.R., 1994, *Quaternary of the Thames*. Geological Conservation Review Services, Joint Nature Conservation Committee. London: Chapman and Hall.

Bridgland, D.R., 2000, 'River terrace systems in north-west Europe: an archive of environmental change, uplift and early human occupation', *Quaternary Science Reviews* 19:1293-1303.

Bridgland, D.R., 2001, 'The Pleistocene evolution and Palaeolithic occupation of the Solent River' in Wenban-Smith, F. and Hosfield, R. (eds.), *Palaeolithic Archaeology of the Solent*. Lithics Studies Society Occasional Paper 7. London: Lithics Studies Society. 15-25.

Bridgland, D.R., Maddy, D. and Bates, M., 2004, 'River terrace sequences: templates for Quaternary geochronology and marine-terrestrial correlation', *Journal of Quaternary Science* 19:203-218.

Clutton-Brock, J. and Noe-Nygaard, N., 1990, 'New osteological and C-isotope evidence on Mesolithic dogs: companions to hunters and fishers at Starr Carr, Seamer Carr and Kongemose', *Journal of Archaeological Science* 17:643-653.

Coles, B., 1998, 'Doggerland: A Speculative Survey', *Proceedings of the Prehistoric Society* 64:45-81.

Dix, J. and Westley, K., 2004, *A Re-Assessment of the Archaeological Potential of Continental Shelves*. University of Southampton (see Online-Resources).

Fedje, D.W. and Josenhans, H., 2000, 'Drowned forests and archaeology on the continental shelf of British Columbia, Canada', *Geology* 28(2), 99-102.

Fischer, A., 1995, 'An entrance to the Mesolithic world below the ocean. Status of ten years' work on the Danish sea floor' in Fischer, A. (ed.), *Man and sea in the Mesolithic: coastal settlement above and below present sea level,* Oxbow Monograph 53, Oxford: Oxbow. 371-384.

Fischer, A., 1996, 'At the Border of Human Habitat: The Late Palaeolithic and Early Mesolithic in Scandinavia' in Larrson, L. (ed.), *The Earliest Settlement of Scandinavia and its Relationship with Neighbouring Areas,* Acta Archaeologica Lundensia Series 8, No. 24:157-176.

Fischer, A., 2004, 'Submerged Stone Age – Danish Examples and North Sea potential' in Flemming, N.C. (ed.) *Submarine prehistoric archaeology of the North Sea*. CBA Research Report 141. York: Council for British Archaeology. 21-36.

Funnel, B.M., 1995, 'Global sea-level and the (pen-)insularity of late Cenozoic Britain' in Preece, R.C. (ed.), *Island Britain: A Quaternary Perspective,* London: The Geological Society. 3-13.

Gamble, C. S., 1999, *The Palaeolithic Societies of Europe.* Cambridge: Cambridge University Press.

Glimmerveen, J., Mol, D., Post, K., Reumer, J.W.F., van der Pflicht, H., de Vos, J., van Geel, B., van Reenen, G. and Pals, J.P., 2004, 'The North Sea project: the first palaeontological, palynological, and archaeological results' in Flemming, N.C. (ed.) *Submarine prehistoric archaeology of the North Sea*. CBA Research Report 141. York: Council for British Archaeology. 43-52.

Godwin, H. and Godwin, M.E., 1933, 'British Maglemose harpoon sites', *Antiquity* 7, 36-48.

Gosden, C., 1999, *Anthropology and Archaeology: A changing relationship*. London: Routledge.

Grøn, O., 1995, 'Research in Stone Age sites at submerged shore zones. Strategies and experiences' in Fischer, A. (ed.), *Man and sea in the Mesolithic: coastal settlement above and below present sea level,* Oxbow Monograph 53, Oxford: Oxbow. 403-408.

Grøn, O. and Skaarup, J., 1993, 'Mollegabett II – Submerged Mesolithic Site and a 'boat burial' from Aero', *Journal of Danish Archaeology* 10:38-50.

Grøn, O. and Skaarup, J., 2004, 'Submerged Stone Age coastal zones in Denmark: investigation strategies and results' in Flemming, N.C. (ed.) *Submarine prehistoric archaeology of the North Sea*. CBA Research Report 141. York: Council for British Archaeology. 53-56.

Hamblin, R.J.O., Crosby, A., Balson, P.S., Jones, S.M., Chadwick, R.A., Penn, I.E., and Arthur, M.J., 1992, *The Geology of the English Channel,* British Geological Survey UK Offshore Regional Report, London: HMSO.

Hansen, L., 1995, 'Submerged Mesolithic landscapes. Preliminary results from the Hanö Bay, Southern Baltic' in Fischer, A. (ed.), *Man and sea in the Mesolithic: coastal settlement above and below present sea level,* Oxbow Monograph 53, Oxford: Oxbow. 409-414.

Hosfield, R., 2001, 'The Lower Palaeolithic of the Solent: 'Site' Formation and Interpretive Frameworks' in Wenban-Smith, F.F. and Hosfield, R. (eds.), *Palaeolithic Archaeology of the Solent River,* Lithic Studies Occasional Paper 7 (Proceedings of the Lithic Studies Society day meeting held at the Department of Archaeology, University of Southampton on Saturday 15 January 2000). 85-97.

Hosfield, R., 2004, 'The Archaeological Potential of Secondary Contexts'. University of Southampton: Unpublished report (see Online-Resources).

Hosfield, R., 2005, 'Palaeolithic and Mesolithic' in Webster, C.J. (ed.), South West Archaeological Research Framework: Draft Resource Assessment. Unpublished report (see Online-Resources) 22-61.

Housley, R.A., Gamble, C. S., Street, M. and Pettitt, P., 1997, 'Radiocarbon evidence for the Late-glacial human re-colonisation of northern Europe'. *Proceedings of the Prehistoric Society* 63:25-54.

Jacobi, R.M., 1979, 'Early Flandrian Hunters in the Southwest' *Proceedings of the Devon Archaeological Society* 13:48-93.

Jelgersma, S., 1979, 'Sea-level changes in the North Sea Basin', in Oele, E., Schüttenhelm, R.T.E. and Wiggers, A.J. (eds.), *The Quaternary History of the North Sea,* Acta Universitatis Upsaliensis: Symposium Universitatis Upsaliensis Annum Quingentesimum Celebrantis 2, Uppsala: Almqvist & Wiksell International. 233-248.

King, M.P., 2006, Human skeletal material from wet contexts in Britain during the Neolithic (middle of the seventh to the end of the fifth millennia BP), Online-report, Appendix 15 (see Online-Resources).

Klein, R.G., 1999, *The Human Career,* Chicago: University of Chicago Press.

Lee, J.R., Rose, J., Candy, I, and Barendregt, R.W., 2006, 'Sea-level changes, river activity, soil development and glaciation around the western margins of the southern North Sea Basin during the Early and early Middle Pleistocene: evidence from Pakefield, Suffolk, UK', *Journal of Quaternary Science* 21:155-179.

Long, A., 2003, 'The coastal strip: sea level change, coastal evolution and land-ocean correlation', *Progress in Physical Geography* 27(3):423-434.

Long, D. Wickham-Jones, C. R. and Buckley, N.A., 1986, 'A flint artefact from the northern North Sea' in Roe, D.A. (ed.), *Studies in the Upper Palaeolithic of Britain and Northwest Europe,* BAR International Series 296.

Louwe Kooijmans, L.P., 1970/1971, 'Mesolithic Bone and Antler Implements from the North Sea and from the Netherlands', *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 20-21:27-73.

Lübke, H., 2002, Steinzeit in der Wismarbucht – Ein Überblick, *Nachrichtenblatt Arbeitskreis Unterwasserarchäologie* 9, 75-88.

Lyell, C., 1872, *Principles of Geology,* London: John Murray.

Malm, T., 1995, 'Excavating submerged Stone Age sites in Denmark – the Tybrind Vig example' in Fischer, A. (ed.), *Man and sea in the Mesolithic: coastal settlement above and below present sea level,* Oxbow Monograph 53, Oxford: Oxbow. 385-396.

Mellars, P., 2006, 'A new radiocarbon revolution and the dispersal of modern humans in Eurasia', *Nature* 439, 2006, 931-935.

Mithen, S., 1999, 'Hunter-gatherers of the Mesolithic' in Hunter, J. and Ralston, I., *The Archaeology of Britain. An introduction from the Upper Palaeolithic to the Industrial Revolution*, London and New York: Routledge.

Momber, G., 2000, 'Drowned and Deserted: a submerged prehistoric landscape in the Solent, England', *International Journal of Nautical Archaeology* 29.1:86-99.

Momber, G., 2001, 'Six fathoms down off Bouldnor Cliff: a Mesolithic site' in Sparks, B., Momber, G. and Satchell, J. (eds.), *A Decade of Diving, Delving and Disseminating. Hampshire and Wight Trust for Maritime Archaeology 1991-2001*, Southampton: Oceanography Centre. 65-69.

Momber, G., 2004, 'The inundated landscapes of the western Solent' in Flemming, N.C. (ed.) *Submarine prehistoric archaeology of the North Sea*. CBA Research Report 141. York: Council for British Archaeology. 37-42.

Momber, G., 2006, 'Mesolithic occupation: 11 m below the waves' in Hafner, A., Niffeler, U. and Ruoff, U. (eds.), *The new view. Underwater Archaeology and the Historical Picture*, Proceedings of the 2nd International Congress on Underwater Archaeology, Rüschlikon bei Zürich, 21.-24. Oktober 2004, Antiqua 40, Basel: Archaeologie Schweiz. 56-63.

Momber, G. and Campbell, C., 2005, 'Stone Age Stove under the Solent', *The International Journal of Nautical Archaeology* 34/1:148-149.

Moran, L., 2003, 'Recent Discoveries off the Coast at Tynemouth', *The School of Historical Studies Postgraduate Forum e-Journal* Edition Two (see Online-Resources).

Parfitt, S. A., Barendregt, R.W., Breda, M., Candy, I., Collins, M.J., Coope, G.R., Durbidge, P., Field, M.H., Lee, J.R., Lister, A.M., Mutch, R., Penkman, K.E.H., Preece, R.C., Rose, J., Stringer, C.B., Symmons, R., Whittaker, J.E., Wymer, J.J. and Stuart, A.J., 2005, 'The earliest record of human activity in northern Europe', *Nature* 438, 1008-1012.

Preece, R.C. (ed.), 1995a, *Island Britain: A Quaternary Perspective,* London: The Geological Society.

Preece, R.C., 1995b, 'Introduction' in Preece, R.C. (ed.), *Island Britain: A Quaternary Perspective,* London: The Geological Society.

Protocol 2006, 'British Marine Aggregates Producers Association (BMAPA) – Protocol for reporting finds of archaeological interest' (see Online-Resources).

Scaife, R., 2004a, 'Seabed in Prehistory (Arun Offshore): Potential for Pollen and Diatom Analysis in Palaeo-environmental Reconstruction'. Unpublished report, see Appendix III.

Scaife, R., 2004b, 'Seabed in Prehistory (Arun Offshore): Pollen Analysis. The early Holocene Vegetation and Changing Habitats of the English Channel Sea-floor'. Unpublished report, see Appendix III.

Schlanger, S.H., 1992, 'Recognising persistent places in Anasazi settlement systems' in Rossignol, J. and Wandsnider, L. (eds.), *Space, time and archaeological landscapes,* New York: Plenum Press.

Shennan, I., Lambeck, K., Horton, B., Innes, J., Lloyd, J., McArthur, J., Purcell, T. and Rutherford, M., 2000, 'Late Glacial and Holocene records of relative sea-level changes in northwest Scotland and their implications for glacio-hydro-isostatic modelling', *Quaternary Science Reviews* 19(11):1103-1135.

Shennan, I., Peltier, W.R., Drummond, R. and Horton, B., 2002a, 'Global to local scale parameters determining relative sea-level changes and the post-glacial isostatic adjustment of Great Britain', *Quaternary Science Reviews* 21(1-3):397-408.

Shennan, I., Lambeck, K., Horton, B., Innes, J., Lloyd, J., McArthur, J. and Rutherford, M., 2002b, 'Holocene isostasy and relative sea-level changes on the east coast of England' in Shennan, I. and Andrews, J.E. (eds.), *Holocene Land – Ocean Interaction and Environmental Change around the North Sea*. Geological Society Special Publication 166. London: The Geological Society. 275-298.

Siddall, M., Rohling, E.J., Almogi-Labin, A., Hemleben, Ch., Meischner, D., Schmelzer, I. and Smeed, D.A., 2003, 'Sea-level fluctuations during the last glacial cycle', *Nature* 423:853-858.

Skaarup, J., 1995, 'Hunting the hunters and fishers of the Mesolithic – twenty years of research on the sea floor of Funen, Denmark' in Fischer, A. (ed.), *Man and sea in the Mesolithic: coastal settlement above and below present sea level,* Oxbow Monograph 53, Oxford: Oxbow. 397-402.

Smed, P., 1987, *Undersøiske fortidsminder - en registrering,* Havbundsundersøgelser Arkæologi. Hørsholm.

Stringer, C. and Gamble, C.S., 1993, *In search of the Neanderthals: Solving the puzzle of human origins*. London: Thames and Hudson.

Stringer, C., 2006, 'The first humans north of the Alps' in Parfitt, S., Stuart, T., Stringer, C. and Preece, R., 'First Britons', *British Archaeology* January February:18-27.

Tappin, D.R., Chadwick, R.A., Jackson, A.A., Wingfield, R.T.R. and Smith, N.J.P., 1994, *United Kingdom offshore regional report: the geology of Cardigan Bay and the Bristol Channel.* London: HMSO for the British Geological Survey.

Verhart, L.B.M., 1995, 'Fishing for the Mesolithic. The North Sea: a submerged Mesolithic landscape' in Fischer, A. (ed.), *Man and sea in the Mesolithic: coastal settlement above and below present sea level,* Oxbow Monograph 53, Oxford: Oxbow. 291-308.

Verhart, L.B.M., 2004, 'The implications of prehistoric finds on and off the Dutch coast' in Flemming, N.C. (ed.) *Submarine prehistoric archaeology of the North Sea*. CBA Research Report 141. York: Council for British Archaeology. 57-61.

Waller, M. and Long, A., 2003, 'Holocene coastal evolution and sea-level change on the southern coast of England: a review', *Journal of Quaternary Science* 18(3-4):351-359.

Waughman, M., 2005, Archaeology and Environment of Submerged Landscapes in Hartlepool Bay, Hartlepool: Tees Archaeology.

Wenban-Smith, F., 2002, 'Marine Aggregate Dredging and the Historic Environment: Palaeolithic and Mesolithic Archaeology on the Seabed'. Unpublished report, Wessex Archaeology ref. 49047 (see Online-Resources).

Wessex Archaeology, 1998a, 'St Catherine's, Isle of Wight – Area 451. Environmental Assessment: Archaeology', Unpublished reprt ref. 44271.03.

Wessex Archaeology, 1998b, 'St Catherine's, Isle of Wight – Area 407. Environmental Assessment: Archaeology', Unpublished reprt ref. 45200.02.

Wessex Archaeology 2007a, 'Seabed Prehistory: Gauging the Effects of Marine Aggregate Dredging. Final Report, Volumes I-VIII', Unpublished report ref. 57422.10-17.

Wessex Archaeology 2007b, 'Draft Technical Advice Note on Geotechnical and Geophysical Survey Methodologies for the Assessment and Evaluation of Prehistoric Seabed Deposits.', Unpublished report ref. 57422.18.

West, R.G., Devoy, R.J.N., Funnell, B.M. and Robinson, J.E., 1984, 'Pleistocene deposits at Earnley, Bracklesham Bay, Sussex', *Philosophical Transactions of the Royal Society of London* B306:137-157.

White, M.J. and Schreve, D.C., 2000, 'Island Britain – Peninsula Britain: palaeogeography, colonisation, and the Lower Palaeolithic of the British Isles', *Proceedings of the Prehistoric Society* 66:1-28.

Wild, E.M., Teschler-Nicola, M., Kutschera, W., Steier, P., Trinkaus, E. And Wanek, W., 2005, 'Direct dating of Early Upper Palaeolithic human remains from Mladec', *Nature* 435, 2005, 332-335.

Wymer, J., 1999, *The Lower Palaeolithic Occupation of Britain,* Wessex Archaeology and English Heritage.

ONLINE RESOURCES

AHOB 2006:
http://www.nhm.ac.uk/hosted_sites/ahob/AHOBI/overview_time_chart.gif

BMAPA website:
http://www.bmapa.org

King, M.P., 2006:
http://acl.arts.usyd.edu.au/projects/externalprojects/mking_lwtd/appendix15.html

Moran, L., 2003:
http://www.ncl.ac.uk/historical/postgrad_forum/ed_2/ed_2_moran.pdf

Hosfield, R., 2004:
http://www.arch.soton.ac.uk/Research/Aggregates//arch-intro.htm

Dix, J., and Westley, K., 2004:
http://www.arch.soton.ac.uk/Research/Aggregates//shelve-intro.htm

Protocol 2006:
http://www.wessexarch.co.uk/projects/marine/bmapa/index.html

Webster, C.J., 2005:
http://www.somerset.gov.uk/somerset/cultureheritage/heritage/swarf/publications/

Wenban-Smith, F., 2002:
http://www.bmapa.org/pdf/palaeo_meso.pdf

Wessex Archaeology 2003/2004:
http://www.english-heritage.org.uk/server/show/ConWebDoc.5671