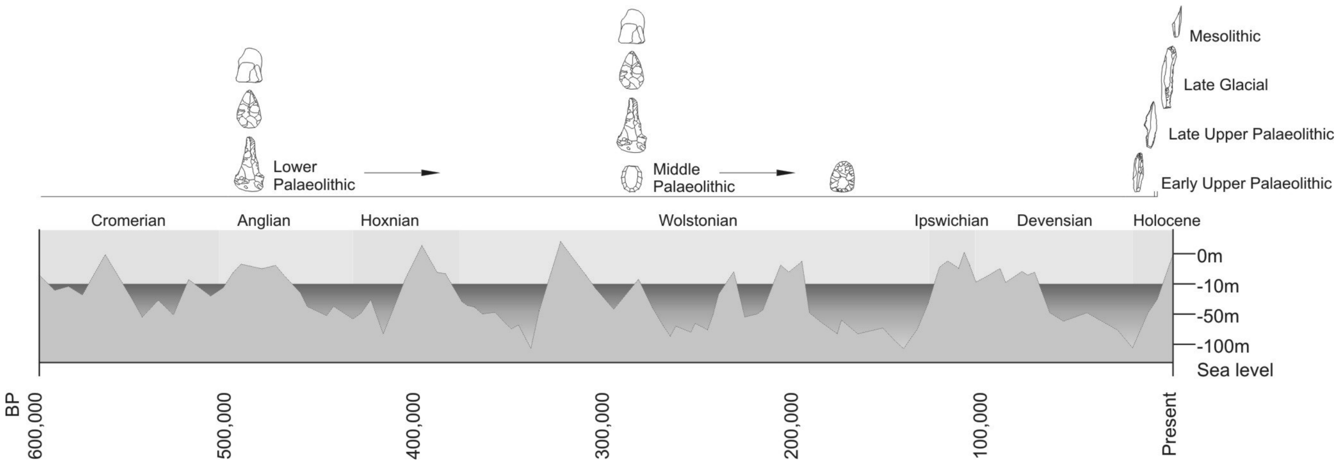
Palaeolithic and Mesolithic Archaeology on the Sea-bed:

Marine Aggregate Dredging and the Historic Environment

Francis Wenban-Smith



Wessex Archaeology

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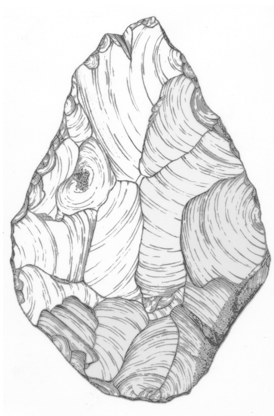

Preface

The British Marine Aggregate Producers Association (BMAPA), as part of its commitment to ensuring the environmental sustainability of marine aggregates extraction, has initiated a project with the Royal Commission on the Historical Monuments of England (RCHME) to ensure effective and practical consideration of the historic environment in the licensing of marine aggregate extraction.

This report is the result of one element of the project, being an attempt to clarify the potential for Lower / Middle Palaeolithic and Upper Palaeolithic / Mesolithic material upon and below the sea bed in areas of marine aggregate deposits.

Other elements of the project include the preparation of maps broadly characterising marine archaeological potential in order to assist in the scoping of archaeological assessments, and the preparation of guidance on assessing, evaluating, monitoring and mitigating significant effects.

BMAPA and RCHME commissioned Wessex Archaeology to carry out the project as a whole. In turn, Wessex Archaeology commissioned Dr. Francis Wenban-Smith of the Department of Archaeology, University of Southampton to prepare this report.

Contents

Acknowledgements

I am grateful to Martin Bates for some preliminary discussions on the subject, and to Paul Cuming of Kent County Council for his investigations of the Kent Sites and Monuments Record for offshore material on my behalf. In particular I would like to thank Antony Firth of Wessex Archaeology and Ian Selby of Hanson Aggregates Marine Ltd for involving me in this exciting pioneering project, and for helpful discussions in the course of production of this report. Mark Russell of BMAPA provided editorial comments.

Summary

This paper constitutes an initial review of the potential for Palaeolithic and Mesolithic archaeological remains in seabed sediments suitable for use as aggregates. Not all such sediments are liable to be extracted as marine aggregate deposits (MADs) due to factors such as the potential implications of extraction for coastal erosion. It was not attempted, however, to distinguish between the archaeological potential of sediments liable to be extracted as MADs, and that of similar sediments not licensed due to their inshore location. Nor was it attempted to be specific about the archaeological potential of any particular bodies of MAD. Rather, the emphasis was on a general consideration of the nature and significance of the archaeological evidence liable to present in the types of sediment exploited as MADs. The conclusion is that Palaeolithic and Mesolithic remains are likely to be present in and/or on several or many MADs, and may well on occasion be highly significant.

Earlier Palaeolithic

Disturbed Lower and Middle Palaeolithic archaeological evidence is likely to be present within many MADs of Pleistocene fluvial origin. Undisturbed horizons may also on occasion be present within these deposits. In general this evidence would be of similar importance to that on land, possibly with an increased potential of good biological preservation

Final Palaeolithic and Mesolithic

Both disturbed and undisturbed final Palaeolithic and Mesolithic evidence with exceptional biological preservation may be present in thin layers of fine-grained deposits (clays, silts, sands and organic-rich sediments) on the surface of any MADs. Undisturbed evidence of this period from underwater context is likely to be of national or international significance in view of the preservation of organic evidence, and the potential for investigation of the post-glacial recolonisation of Britain and the North Sea based Mesolithic adaptation.

The Way Forward

Having recognised the potential for MADs to contain Palaeolithic and Mesolithic archaeological evidence, it is necessary to consider how the presence, nature and significance of such archaeological remains can be:

- predicted or identified in advance of licensing or extraction;
- studied in advance of, or in conjunction, with extraction.

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1. Introduction

1.1 Project Background

This paper is the first product of a joint initiative by the British Marine Aggregates Producers Association (BMAPA) and the Royal Commission on the Historical Monuments of England (RCHME, now English Heritage) to promote environmentally responsible and sustainable sea-bed development with respect to marine archaeological issues. The potential presence and archaeological significance of wrecks on the sea-bed has been recognised for several decades and is well integrated into the licensing process for sea-bed development. In contrast, although it has been recognised since the early 20th century that archaeological remains of prehistoric human habitation are also present on the sea-bed, which contains sediments dating from throughout the last 500,000 years and much of which has only been submerged for the last 5,000 years, the impact of sea-bed development upon this evidence has hitherto been little considered. The purpose of this paper is to take the first steps in considering whether marine aggregate extraction has any potential Palaeolithic and Mesolithic archaeological impact, to signpost future steps towards prediction and mitigation of any impact and, above all, to stimulate further discussion from both sea-bed developers and archaeologists. Thus any criticisms and comments are wholly welcomed, with a view to moving beyond this preliminary discussion document towards a more definitive statement of both policy and practice.

1.2 Marine Aggregate Deposits

Marine aggregate deposits (MADs) are sands and gravels of economic value that occur on the sea-bed in certain places in coastal waters. Marine aggregates are used primarily for building and construction purposes (cement, concrete etc.), and around 21% of all sand and gravel used in England and Wales comes from marine sources. Deposits suitable as MADs comprise well-defined bodies more than 0.5m thick of well-sorted hard rock gravels in the size-range *c.* 2–40mm, without a covering of clay, silt or organic-rich over-burden, and with a minimum of such fine-grained sediments associated in the matrix. It is important to realise that these deposits are very similar in composition and formation to those found in terrestrial sand and gravel pits worked by the quarrying industry. In many cases the depositional conditions in which terrestrial deposits were formed are analogous to those forming MADs (see Section 2.3) – many of which represent submerged terrestrial deposits. With land-based sand and gravel workings having resulted in many significant archaeological finds, so the potential for MADs to contain similar evidence is compelling. Intensive surveying of British coastal waters over the last few decades has mapped this resource and identified areas of maximum potential. Significant MADs are present in two main areas: the southern North Sea and the English Channel (Figure 1), with less extensive deposits present in the Bristol Channel and in the Irish Sea. The MADs exploited in the Bristol Channel/Irish Sea regions have been excluded from this review because the commercial deposits primarily comprise well-sorted sands in bank/sheet formations. Consequently, rather than representing *in situ* deposits, the sediment present will have been subject to extensive marine sorting and transport processes, prior to the formation of the deposits as they are found now. As a result, the potential for Palaeolithic/Mesolithic evidence is considered less likely.

In the southern North Sea, MADs have been identified in the Humber Estuary, the Thames Estuary and off-shore to the east of East Anglia, opposite Great Yarmouth, Southwold and Orford Ness (Cameron *et al.* 1992: 117, Figure 111). Those in the Humber Estuary are last glacial glacigenic outwash gravels, and the remainder are of Pleistocene fluvial origin, generally preserved in terraces on the flanks of submerged valley systems or filling palaeo-channels (eg. see Bridgland *et al.* (1993) for detailed mapping in the Thames Estuary). In the English Channel, MADs have been identified at several locations off the south coast, to the west and east of the Isle of Wight, off Worthing, Brighton and Hastings, and in the Eastern English Channel (Hamblin *et al.* 1992: 79, Figure 62 and p. 83, Figure 63). These deposits are mostly, if not all, also of Pleistocene fluvial origin. Some may, however, be of marine coastal origin, representing submerged Pleistocene storm beaches or gravel bars.

The superficial sea-bed sediments that comprise MADs have mostly been formed during the Middle and Late Pleistocene, contemporary with the first human colonisation and subsequent occupation of Britain and north-west Europe up until the end of the last ice age (the Palaeolithic period). Changing climate and sea-level during this time-span periodically exposed the sea-bed as dry land, creating a surface for human occupation, and the potential for associated archaeological evidence to be preserved within contemporary deposits, formed by subaerial terrestrial

Figure 1. Licensed marine aggregate deposits (MADS) in the southern North Sea and English Channel

processes although subsequently, and often repeatedly, submerged by rising sea-level. Following the end of the last ice age, during the Holocene, sea-level rose towards that of the present day progressively submerging the post-ice age landscape, which was occupied by final Palaeolithic and Mesolithic hunter-gatherers. Not all deposits containing, or potentially containing, archaeological evidence are desirable as MADs, and conversely not all MADs are liable to contain archaeological evidence, depending upon their mode and period of formation. However many MADs clearly have the potential *a priori* to contain Palaeolithic archaeological evidence within their main body and/or final Palaeolithic/Mesolithic evidence upon their surface. The aim of this paper is to review the potential presence and significance of Palaeolithic and Mesolithic evidence within MADs, as a foundation for subsequent development of appropriate mitigation strategies to accompany plans for extraction.

1.3 Licensing and Heritage Impact Assessment

As the property of the Crown, mineral rights for MAD extraction are administered through the Marine Estates division of the Crown Estates, whilst permission to dredge is granted by the Department for Transport, Local Government and the Regions (DTLR). Environmental impact assessments are an integral part of the licensing process, and it is becoming increasingly recognised that sea-bed development can have an impact on the archaeological heritage, whether on wrecks, on late prehistoric or early historic sea-floor archaeological remains from inhabitation of the surface of MADs prior to submergence by Holocene marine transgression, or on early prehistoric archaeological evidence incorporated within MADs. The statutory framework under which any impact upon the cultural resource will be assessed and mitigated is currently in a state of flux, although it appears likely that English Heritage will shortly adopt a formal advisory role.

1.4 Objectives

Having recognised the potential for MADs to contain archaeological evidence within them or on their surface, the purpose of this paper is to consider in more detail their potential in relation specifically to Palaeolithic and Mesolithic evidence. It is beyond the scope of this paper to provide a specific evaluation of the Palaeolithic and Mesolithic archaeological potential for each and every part of the vast British MAD resource, or to consider the potential of the great quantity and diversity of sea-bed sediments which are not desirable as MADs. Nor is it within the remit to consider, or even take account of, the practical difficulties of evaluating and researching off-shore Palaeolithic and Mesolithic archaeological evidence. Rather, the goal of this project is to consider in a more general way:•Presence Whether any Palaeolithic and/or Mesolithic archaeological evid-ence is likely to be present in/on deposits currently identified as viable MADs in the southern North Sea, the Thames Estuary and the English Channel.

- Nature — The nature of any such evidence.
- Significance — The significance of such evidence within the context of current research frameworks.
- Impact — The potential degree of impact of marine aggregate extraction upon the Palaeolithic and Mesolithic archaeological resource.
- Consequences — The consequent potential effects – adverse and/or beneficial – of MAD extraction upon the conservation, understanding and appreciation of the historic cultural environment
- Problems — Speecific problem areas where

further research would be fruitful can be identified as a result of this preliminary consideration?

1.5 Approaches

These issues have been approached through certain more specific themes:

- Formation — What were the formation processes and periods of any MADs?
- Inhabitation — Was the chronology and distribution of human settlement such that any Palaeolithic or Mesolithic archaeological remains are likely to be present in MADs?
- Preservation — What depositional and post-depositional processes have been operating in MADs, and what are the implications – adverse and/or beneficial – for the preservation and interpretive potential of any archaeological material?
- Importance — How significant are any likely archaeological remains within MADs within the context of international, national and regional frameworks of research?
- Distribution — Are there any preliminary indications of the location and distribution within MADs of deposits of highest potential significance?
- Indicators — Is there any potential in the existing records of archaeological material for evaluating the Palaeolithic and Mesolithic archaeological potential of MADs, and what sorts of indicators might be useful?
- Impact — Based on known existing and proposed areas of MAD extraction, is their likely to be an impact on any potentially significant archaeological remains?

2 Background

2.1 Quaternary Context

Chronology and climatic fluctuation

The initial human occupation and subsequent settlement of Britain and north-west Europe has taken place against the backdrop of the Quaternary period, characterised by the onset and recurrence of a series of glacial–interglacial cycles. Over 60 cold–warm cycles have been identified in the Quaternary, corresponding with fluctuations in the proportions in deep-sea and ice records of the Oxygen isotopes O^{16} and O^{18}. These isotope stages have been numbered by counting back from the present-day interglacial (OI Stage 1), with interglacials having odd numbers and glacials even numbers (Figure 2, column B), and dated by a combination of radiometric dating, biostratigraphic correlations and tuning to the astronomical timescale of orbital variations which are now known to have been a fundamental causative agent of the Quaternary climatic fluctuations (Imbrie *et al.* 1984).

Terrestrial sequences from Britain and Holland have been integrated into the global OI framework (Figure 2, columns C and E). OI Stage 1, the current interglacial, began *c.* 10,000 BP (years before present) and it is generally agreed that OI Stages 2–5d, dating from *c.* 10,000 to *c.* 115,000 BP cover the last glaciation (Devensian in Britain, Weichselian in Holland), and that Stage 5e dating from *c.* 115,000 to 125,000 BP correlates with the last, Ipswichian/Eemian interglacial. Beyond that disagreement increases, although many British workers feel reasonably confident in accepting that OI Stage 12, which ended abruptly *c.* 425,000 BP, correlates with the major British Anglian glaciation when ice-sheets reached as far south as the northern outskirts of London (Bridgland 1994). The first proven human occupation of Britain took place in the pre-Anglian interglacial OI Stage 13 *c.* 500,000 BP, so any deposits dating to older than this are of no potential archaeological significance. Recent finds on the Norfolk coast have, however, suggested the possibility of earlier occupation in OI Stage 15, and if this is confirmed, then other deposits of this age would have also to be regarded as of potential significance.

Climate and environment

The latitude of Britain is sufficiently northerly that we have been particularly affected by the Quaternary climatic fluctuations. The climate was sufficiently cold in the glacial periods for much of the country north of London to have been periodically covered by ice-sheets 1–2km thick (Figure 3). At peak interglacials the climate was similar to the present day, and occasionally milder, leading to the melting of the ice sheets. For the majority of the Quaternary, however, the climate was generally cooler than the present day, in a state of flux between peaks of warmth and cold. These changes, although occasionally rapid and marked from the perspective of geological time, would however have been too slow to have been noticed at the scale of a human lifetime. These climatic fluctuations were accompanied by changes in the flora and fauna, with periodic recolonisation by warmth loving species in interglacials, and their disappearance and replacement by cooler loving species in glacials.

Judging from the archaeological evidence of this period, early humans were capable of surviving in all these environments (Roebroeks *et al.* 1992), although there must have been a limit to how close to the ice - sheets they could survive in peak glacial periods.

Sea-level

Intrinsically associated with the climatic fluctuations which characterise the Quaternary are accompanying rises and falls in sea-level. As global water becomes

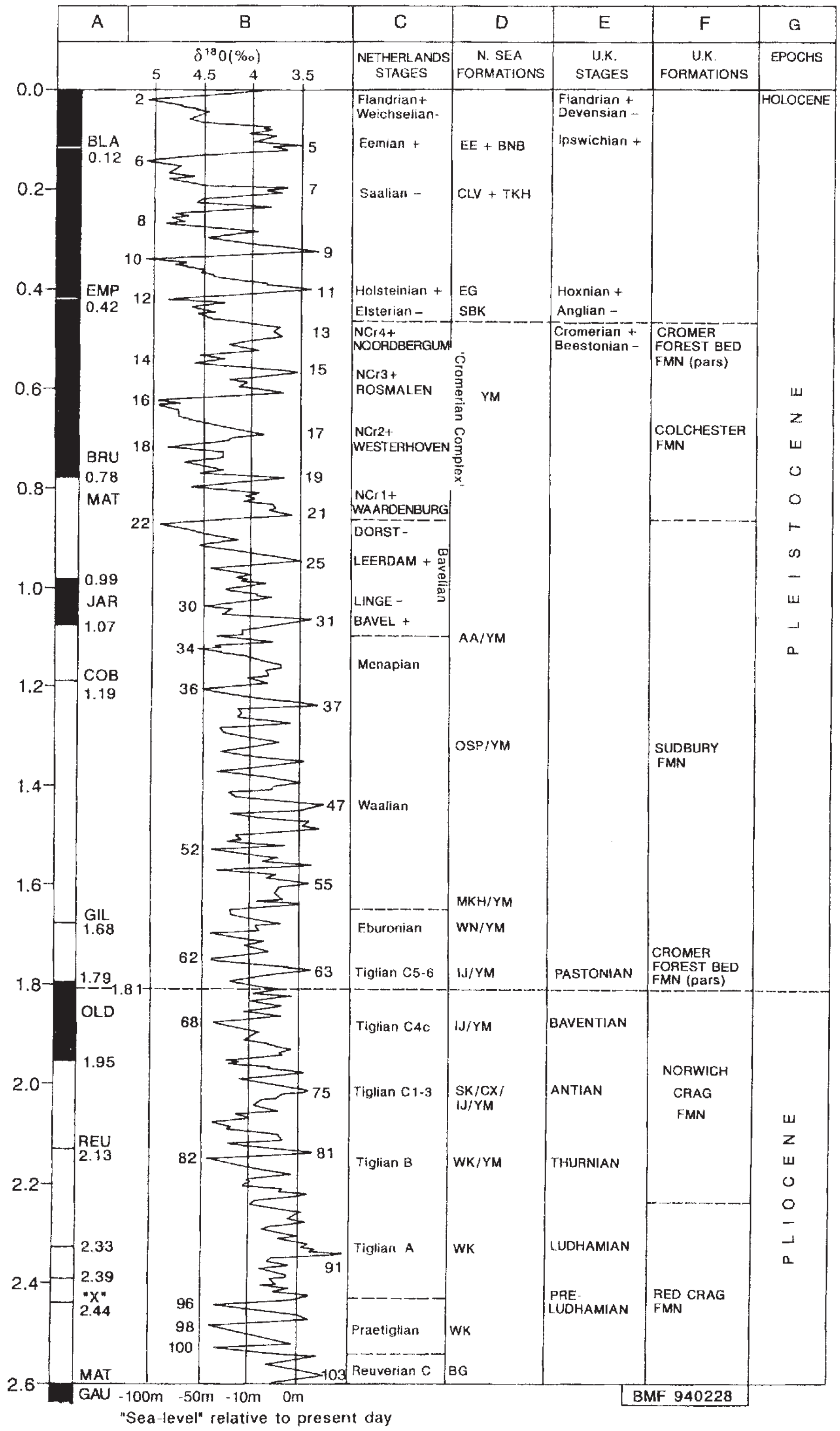

Figure 2. North Sea basin Quaternary stratigraphy. Oxygen Isotope chronology and sea-level change (Funnell 1995: 4)

locked up in ice-sheets the sea-level falls, and conversely when glaciers melt, sea-level rises. This eustatic component of sea-level provides the dominant influence on the relative land–sea levels around Britain. However the history of sea-level in British waters has also been affected by other factors including the isostatic rebound of the landmass once the weight of ice has been removed after melting, and by the underlying tectonic movement of the earth's crust. Several studies have indicated that the North Sea basin is subsiding and that southern England is rising (eg. Long & Tooley 1995), and this has implications both for dating

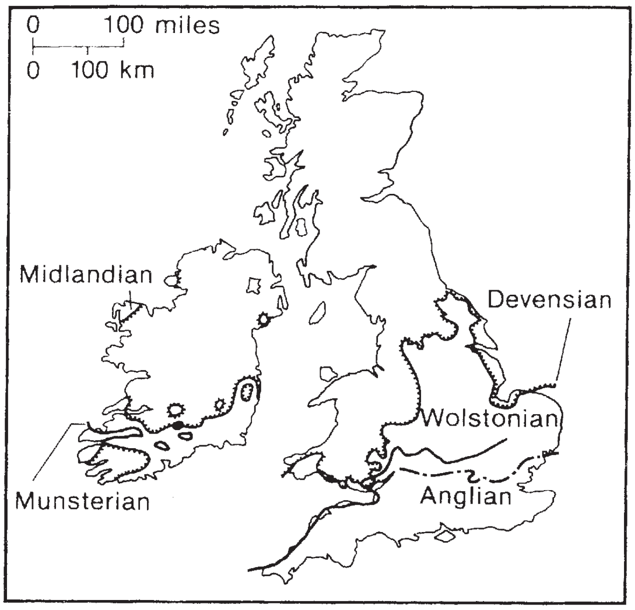

Figure 2. Limits of main Devensian, Wolstonian and Anglian ice-sheet advances in England (Stuart 1982: 9)

Pleistocene formations and also for consideration of the potential significance of various British MADs.

At peaks of glaciation, enough water was locked up in ice-sheets to cause sea-levels to fall by *c.* 125m (Chappell & Shackleton 1986; Figure 2, column B). Within the context of British MADs this is enough to expose the whole English Channel and North Sea as dry land, with the continental shelf forming a coastal plain. In fact, much of the Channel and North Sea is less than 40m deep with only occasional deeper trenches and hollows (Figure 4; Cameron *et al.* 1992: 118, Figure 112; Hamblin *et al.* 1992: 5, Figure 4), so even much less drastic falls in sea-level can have a major impact on the location of the shoreline. The present-day sea-level, corresponding with fully interglacial conditions, represents one extreme of the typical range within the Quaternary; throughout the majority of the Quaternary a substantial proportion of the current North Sea and Channel floor has been dry land.

Depositional processes

The climatic fluctuations of the Quaternary led to the formation of sediments by a range of depositional processes associated with the periodic glacial and interglacial conditions, as well as processes specific to the transitional periods between these climatic extremes. Quaternary archaeological evidence has only been preserved through its incorporation within Quaternary sediments. An understanding of these processes is, therefore, essential in order to interpret any archaeological evidence, and to assess the potential for, and possible significance of, any archaeological content in deposits not yet investigated.

Of particular relevance is the inter-relationship between climatic change and the evolution of river valleys. One of the foundations of the understanding of the British and northwest European Quaternary sequence and its associated Palaeolithic archaeology has been the evidence from the terrace sequences of rivers such as the Thames and Somme. Bridgland (2001) has formulated a six-stage model (Figure 5), where downcutting of river channels and primary aggradation of gravels takes place towards the end of glacial periods accompanying the onset of climatic amelioration. This channel then fills with finer interglacial deposits that are then sandwiched by a second layer of coarser cold-climate gravels at the onset of the subsequent glaciation, and then a further cycle of downcutting is initiated by the onset of the next warmer phase. Sonar observations have shown that in the offshore context, clear terracing is not always present, and single bodies of sediment can contain numerous episodes of incision and aggradation dating to several climatic cycles.

2.2 Palaeolithic and Mesolithic

Britain was first inhabited *c.* 500,000 BP in the pre-Anglian interglacial (OI Stage 13), as evidenced at the site of Boxgrove (Roberts & Parfitt 1999), and the Palaeolithic covers the time span from this initial colonisation to the end of the last glaciation. The Mesolithic covers the subsequent period in the first half of the current interglacial, until the inhabitants of Britain adopted a more settled, Neolithic farming way of life *c.* 5,000 years ago. Thus the Palaeolithic period occupies approximately 490,000 years, and includes at least 4 major glacial–interglacial cycles accompanied by dramatic changes in climate, landscape, environmental resources and depositional conditions, and the Mesolithic occupies approximately 5,000 years corresponding to the climatic amelioration of the first half of the current interglacial (Table 1).

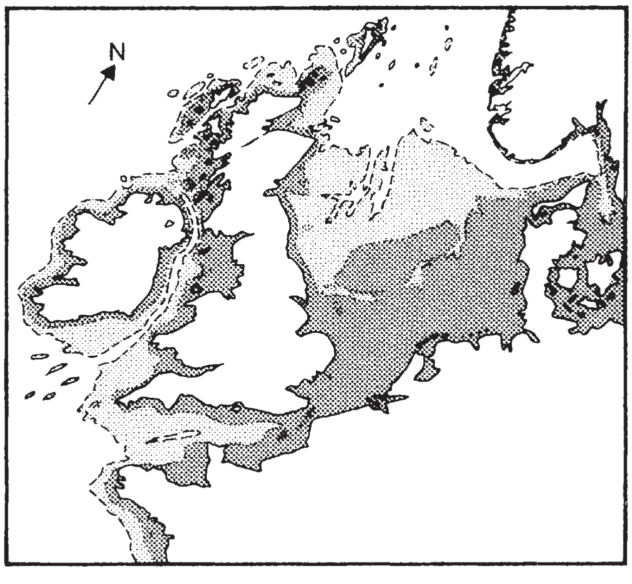

Figure 3. 50m (dark shaded) and 100m (light shaded) sub-marine contours in North Sea and English Channel (Stuart 1982: 18)

Archaeological Period		*OI Stage*	*Date (BP)*	*Human Species*
Mesolithic		1	10,000–5,000	Anatomically modern humans *Homo sapiens sapiens*
Palaeolithic	Upper	3–1	35,000–10,000	Anatomically modern humans *Homo sapiens sapiens*
	Lower/Middle	13–3	500,000–35,000	Archaic Homo – *Homo* cf *heidelbergensis* initially, evolving into *Homo neaderthalensis*

Table 1. Palaeolithic and Mesolithic periods, summary

The earlier, Lower and Middle parts of the Palaeolithic period saw the gradual evolution of an Archaic hominid lineage from the first colonisers of Britain (*Homo heidelbergensis*) into Neanderthals during the period up to the middle of the last glaciation (*c.* 35,000 BP). Around this point in time Neanderthals were suddenly replaced in Britain and north-west Europe by anatomically modern humans. This later part of the Palaeolithic is known as the Upper Palaeolithic, and is associated with changes such as the development of bone and antler tools and the representation of images of animals painted on cave walls or as small antler or bone carvings. The suddenness of this change and the physiological differences between Neanderthals and modern humans, as well as recent DNA studies, suggest that modern humans did not evolve from Neanderthals, but evolved elsewhere, probably in Africa or western Asia *c.* 125,000 BP, before colonising other parts of the world. The transition from Upper Palaeolithic to Mesolithic did not involve any change in human species, but is identified from changes in lithic artefacts in the archaeological record corresponding with the transition from the end of the last glacial to the beginning of the current interglacial *c.* 10,000 BP.

Palaeolithic and Mesolithic occupation was based upon mobile lifestyles dominated by hunting, gathering and scavenging food and other resources. The main archaeological evidence of these periods is not, therefore, structural, but is the scatters of lithic artefacts (stone tools and waste flakes from their manufacture) left behind in the landscape. The robustness and chemical stability of stone means that these are almost indestructible once created, although subject to disturbance by geological depositional and post-depositional processes. Consequently our understanding of these periods has, historically, been underpinned by characterising them in terms of the distinctive stone artefacts made at different periods. However, organic evidence can also be preserved, and this can provide a fuller insight into the behaviour at sites through analysis of, for instance cut marks on bones indicating their use as food, as well as the local climate and environment at the time of occupation through analysis of, for instance, mollusc and plant remains.

Frameworks for research

Research over the last century has provided a fairly full, although not yet complete, understanding of the basic framework of lithic technological and typological change through the Palaeolithic and Mesolithic, and current research is more concerned with addressing more social and behavioural themes (*cf.* English Heritage 1991; Gamble 1999).

Key themes identified for the British Palaeolithic and Mesolithic include:

- Processes of change
- Colonisation
- Settlement
- Behaviour
- Social organisation

Each of these themes embraces a range of more specific research priorities and questions. Amongst the issues highlighted as of importance recently are:

- Investigating the correspondence of physical evolutionary change with Palaeolithic material cultural and behavioural change.
- The timing, duration and geographical distribution of colonisation and settlement in Britain and north-west Europe in relation to climatic and environmental conditions.
- Fuller documentation and explanation of material cultural change through the Palaeolithic and Mesolithic.
- Interpretation of the archaeological evidence at specific sites in more behavioural terms.
- Integration of the activities represented at sites as part of a wider regional pattern of behaviour.
- Developing an understanding of settlement systems within the landscape context and in relation to the distribution of natural resources.
- The nature of social interactions and societies.
- The transition from the Mesolithic to the Neolithic:
  - was it a lifestyle change by an indigenous community?

- does it reflect colonisation from abroad?
- did hunter-gatherer and farming communities co-exist and if so how?

As emphasised in *Exploring our Past* (English Heritage 1991) undisturbed remains, with their high spatial and stratigraphic integrity, are best for answering specific questions about behaviour at sites, particularly when found in association with biological evidence. Such sites are, however, extremely rare. It is recently becoming clear that archaeological material from more disturbed contexts can complement un-disturbed material, providing a more reliable sample of material culture over a broader area from a broader time period and allowing larger scale questions concerning the changing distribution and environmental context of human occupation to be addressed (*cf.* Wenban-Smith & Bridgland 2001). Furthermore, given the importance of chronology and environment in Palaeolithic and Mesolithic research, it needs to be recognised that the current improved understanding of the complex Quaternary chronological and climatic framework has been constructed by the integration of the biological and dating evidence from thousands of sites and horizons lacking any direct archaeological evidence. The study of such sites is, nonetheless, an essential part of archaeological investigation, providing the key to dating many sites, even ones themselves lacking biological evidence, and enabling investigation of issues such as the contemporary environment around activity areas and the broad landscape distribution of occupation.

An important point to bear in mind is that humans in the Palaeolithic and Mesolithic lived on land-surfaces, not in deposits. The general absence of structures and features such as earthworks and pits means that none of the archaeological evidence from these periods was ever buried through human action. It is only through the action of natural depositional processes specific to certain climatic conditions and locations in the landscape that Palaeolithic and Mesolithic archaeological material became incorporated in sediment, and protected for subsequent discovery and interpretation. Therefore, in order to consider the nature and significance of archaeological evidence from different deposits, it is necessary to look at the effects of depositional and post-depositional processes associated with its preservation.

Depositional contexts

The long duration of the Palaeolithic period, and its association with recurring cycles of climatic change, has meant that its archaeological evidence has been subject to a wide range of depositional and post-depositional processes, some of them quite destructive. Once any evidence had been incorporated in sediment, it could remain there until affected by modern interference, or it may, depending upon its position within the landscape, have been further affected by processes associated with subsequent climatic change. The depositional contexts of the Mesolithic period are, however, restricted to those characteristic of the onset of interglacial conditions, and hence are a subset of the wider range associated with Palaeolithic evidence. The main depositional contexts from which Palaeolithic and Mesolithic archaeological material has been recovered in or under are summarised below (Table 2), and an estimate provided of how much disturbance material from these contexts has usually suffered on a 5-point scale – none, minimal, minor, moderate, major. The table also shows which types of deposits have been identified as of potential for MAD extraction on a 3-point scale – yes (✓), maybe (?), no (X).

Although the British Palaeolithic record is dominated by fluvial and colluvial sediments containing disturbed material, this brief summary emphasises the wide variety of contexts that have the potential to contain un- or little-disturbed archaeological material. Biological evidence, particularly smaller and more delicate remains such as small vertebrates and molluscs, is generally better preserved and most usefully studied in finer clay, silt and sand sediments, although coarser-grained gravel-rich sediments from more active depositional contexts also often contain biological evidence when chemical conditions have been suitable. Anaerobic conditions also favour the preservation of biological evidence, and these are often found in waterlogged sites, or sites which initially formed under anaerobic conditions, so depositional environments such as lacustrine, fluvial or estuarine silts and clays, and peats might *a priori* be expected to have a higher potential for organic preservation.

2.3 Marine Aggregate Deposits and their Palaeolithic/Mesolithic Potential

Bearing in mind the Quaternary history of climatic and sea-level fluctuations (*cf.* Figure 2, column B), and that we are currently at a peak of sea-level, it is clear that many sea-bed sediments in the North Sea and English Channel, and specifically MADs, are not marine deposits, but submerged terrestrial deposits. The archaeological potential of such deposits can, therefore, be assessed from a similar perspective to those currently on *terra firma*, once their nature and origin as terrestrial deposits has been established. However, the corollary of the current high sea-level is that there is little evidence on land of marine sediments and the impact of marine inundation upon terrestrial sediments, a post-depositional process not hitherto relevant to Palaeolithic studies and one whose possible effects need to be considered. Furthermore, there has not been just a single inundation, but a series of inundations divided by the repeated action of sub-aerial terrestrial processes associated with climatic deterioration and subsequent amelioration. With this in

General class	*Context*	*Disturbance*	*Potential as MAD*
Glacigenic	Tills	Major	✓
Fluvio-glacial	Outwash sands/gravels	Major	✓
Fluvial	Gravel	Minor to major	✓
	Sands	Minimal to minor	✓
	Alluvial floodplain	None to minor	?
Aeolian	Loess	None	X
	Dunes	None to moderate	X
Lacustrine	Clays, silts	None to minor	X
	Peats	None to minor	X
Coastal marine	Storm beach	None to moderate	?
	Scree, rockfalls	None to moderate	X
	Intertidal sands/silts	None to moderate	?
Estuarine	Intertidal sands/silts	None to moderate	?
	Peats	None to minor	X
Colluvial	Solifluction gravels	Minor to major	X
	Slopewash	None to major	X
Cave deposits	Occupational debris	None to minor	X
	Scree, rockfalls	None to moderate	X
	Cave earth	None to minor	X
Residual deposits	Clay-with-flints	None to major	X
Buried land-surfaces	Soils	None to minor	?

Table 2: depositional contexts of Palaeolithic/Mesolithic archaeological evidence, and their potential as a target for marine aggregate extraction

mind, a division has been made for this project between:

a) the potential for archaeological evidence in sediments formed before the last glacial maximum at *c.* 18,000 BP, ie. which have undergone repeated cycles of sea-level regression, sub-aerial processes associated with climatic deterioration, peak glaciation, climatic amelioration, peak climatic warmth and inundation; this time period covers the later Middle and Late Pleistocene and includes the Lower and Middle Palaeolithic, and the majority of the Upper Palaeolithic;

b) the potential for archaeological evidence in sediments formed since the last glacial maximum, which have undergone a relatively short period of sub-aerial exposure, and been subject to processes associated with a single climatic amelioration and subsequent inundation; this time period covers the final Late Pleistocene and the Holocene and includes the final Late Upper Palaeolithic and the Mesolithic.

This separation has been based upon both a natural break in the landscape history record in British waters, and on an accompanying break in the human occupation record of the region. By the time of the last glacial maximum, the sea-level would have dropped to below –100m OD and the majority of the North Sea and English Channel would have been exposed as dry land. The landscape would have been devegetated and subject to fluvial downcutting and cold-climate processes for many thousands of years and so would have reached a point of relative sedimentary stability. The archaeological record indicates a complete absence of human presence in Britain and its off-shore environs during the last glacial maximum between *c.* 20,000 and 13,000 BP. The last glacial maximum has the added advantage of being a well-defined and dated point in the Quaternary chrono- and litho-stratigraphic record.

3 Lower, Middle and Early Upper Palaeolithic

3.1 Formation

The MADs identified in the study area have mostly been formed by fluvial processes, and represent submerged river terrace systems on the flanks of palaeo-valley systems that are downstream continuations of Pleistocene river systems whose upper reaches are currently exposed above sea-level. These are often likely to be broadly equivalent to Middle and Late Pleistocene terrestrial deposits, and it should be possible to make correlations of individual gravel bodies with individual OI Stages and terrestrial equivalents by matching their downstream channel profiles, for instance as achieved in the Solent region by Dyer (1975) and in the Thames Estuary by Bridgland *et al.* (1993). In these areas it is clear that sequences of up to three separate terraces are still preserved and identifiable. Following Bridgland's model for river valley development and sediment aggradation (Figure 5), the remnant fluvial terraces which constitute the

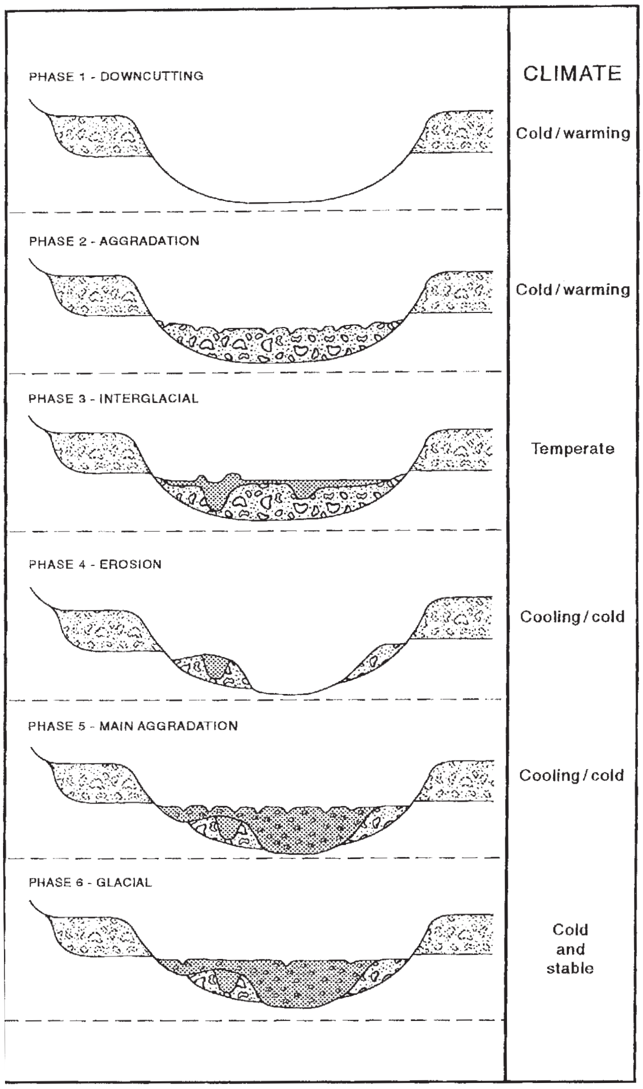

Figure 5. Evolution of river terrace systems in conjunction with Quaternary climatic change (Bridgland 2001)

bulk of the identified MAD resource were probably formed during the post-interglacial maximum cooling phase of the climatic cycle, although these might seal similar deposits from the warming phase of the preceding glaciation. Glacigenic outwash gravels are present in the Humber Estuary and can be related to the general period of the peak of the last glaciation. It is also possible that some MADs off the Sussex coastline may be storm beaches or gravel bars of marine/coastal origin, particularly at Shingle Bank opposite Hastings (Hamblin *et al.* 1992) although Selby (pers. comm.) suggests these are also of fluvial terrace origin. If these are marine, their dating would be more problematic as still-stands in sea-level leading to the formation of such deposits could date to any time in the later Middle and Late Pleistocene, although this would still put them in the frame for being of Palaeolithic potential.

No deposits of solifluction origin have been identified as MADs. Such deposits would not be desirable as MADs due to their poorly sorted nature, and the higher proportion of clays and silts within them compared to fluvial or glacigenic outwash deposits.

Study area	*Process*	*Period (OI stage)*
Humber estuary	Glacigenic: outwash	2
Off East Anglia	Fluvial: terraces and channel fills	20–0 (estimated range)
Thames Estuary	Fluvial: terraces and channel fills	20–2 (estimated range)
English Channel	Fluvial: terraces and channel fills	20–2 (estimated range)
	Marine/coastal: storm beaches, offshore bars	13–3 (estimated range)

Table 3. Formation process and periods of MADs

3.2 Inhabitation

Sea-level has dropped by over 100m twice between the beginning of the British Lower Palaeolithic and the last glacial maximum – in OI Stages 10 and 6 – and by over 50m on at least four other separate occasions – once in OI Stage 12, twice in OI Stage 8 and once in OI Stage 4. Furthermore sea-level was at least 50m below that of the present day for *c.* 40% of this period and at least 10m below for *c.* 65% of this period. The relative influence of tectonic movement is an unknown factor, and one currently subject to debate. If there is a differential east–west tilt as postulated by Long and Tooley (1995) then more easterly areas would have been higher and drier and more westerly areas less liable to emergence than predicted from basic sea-level change. Notwithstanding the element of uncertainty introduced by crustal movement, it is clear that for much of the relevant time period, substantial areas of the Channel and North Sea would have been dry land.

Given that the landscape was exposed, it is necessary to consider whether it was also habitable in the colder conditions inevitably accompanying its exposure. Climatic conditions would probably have led sea-level change rather than lagged behind it, so one can assume that as the landscape emerges climatic conditions are already cold or cooling. An insight into the climatic tolerances of the Archaic hominids of this period can be gained from what is already known from deposits of this period preserved on dry land. Occupation at Boxgrove for instance, occurs towards the end of the pre-Anglian interglacial when falling sea-level has exposed the main marine Slindon Silt unit as a grassy plain, and undisturbed knapping debitage has been found on temporary landsurfaces within the cliff-collapse sediments and the main solifluction units associated with the onset of full glaciation (Roberts &

Parfitt 1999). This suggests continuing hominid occupation beyond the Boxgrove temperate episode and into at least the onset of glacial climate. Other cold stages with low sea-levels within the period under discussion are OI Stages 10, 8, 6 and 4. Pinning down hominid occupation to any of these stages is problematic due to the preponderance of derived material, and the lack of dating precision in this range, although they probably did not differ significantly in climate from OI Stage 12. On the nearby continent, there is evidence of human occupation during OI Stage 8 at Mesvin IV in Belgium where the accompanying fauna include cold-adapted species such as arctic fox, woolly rhino, reindeer and mammoth (Roebroeks & Tuffreau 1999) and OI Stage 6 at La Cotte de St Brelade in Jersey (Callow & Cornford 1986), although it is suggested that hominids were not present here at the peaks of cold climate but only in the milder interstadials.

Following the interglacial peak of OI stage 5e there is a marked contrast in the last glacial Middle Palaeolithic settlement of northern France and Belgium on the south side of the Channel, and southern England on the north side. Sites dating to this period, ie. between *c.* 115,000 BP and 40,000 BP proliferate in France and Belgium, both in caves and rockshelters, and also in the open air in the thick deposits of loess characteristic of the continental last glacial depositional record. Contrastingly in England a few, slightly unreliably dated cave and rockshelter sites are known such as Coygan Cave, last glacial loess is virtually absent and no loessic open air sites have been found. There is a general background noise of lithic artefacts which appear characteristically late Middle Palaeolithic – *bout coupé* handaxes – but no major sites are known. This would suggest that the offshore landscape above –50m OD was potentially inhabited, when exposed, throughout the period, although for some reason more sparsely on the English side of the Channel than the French.

At around 35,000–30,000 BP Neanderthals were replaced in northwestern Europe by modern humans, a transition directly observable in several northwestern continental sites such as the Belgian cave of Spy, and indirectly inferrable in a few British sites (Aldhouse-Green & Pettitt 1998), and there are several C^{14} dates reflecting modern human presence in Britain in the period 30,000 BP to 21,000 BP, ie. right up to the severe cold of the last glacial maximum.

In general cold climate does not seem to have been much of a bar to Archaic or modern human occupation, although the glaciated and immediately adjacent periglacial zones would probably have contained too few resources for viable settlement. However, peaks of glaciation would have occupied only relatively short periods of the time-span under consideration, and it is probable that humans would have been occupying the off-shore landscape for the majority of the time during its regular exposure by lower sea-levels. There seems to have been a shift away from open-air activity towards cave and rockshelter activity following the last interglacial and accompanying the development of Neanderthals and the Middle Palaeolithic period, and the subsequent Upper Palaeolithic and the appearance of modern humans. This would lead to a decreased potential for the recovery of material from these later periods in the river terrace gravels which constitute the majority of MADs, although Middle Palaeolithic material is occasionally found in such a situation.

3.3 Preservation

The depositional and post-depositional processes operating on archaeological evidence on the off-shore landscape prior to its inundation by marine transgression would be the same as those known from terrestrial Palaeolithic studies. The river gravels which form the majority of the MAD resource reflect an active depositional environment in which archaeological material would have been gathered from the channel banks, and possibly bars, as it migrated within the floodplain, and subsequently transported, mixed and reworked. It is currently uncertain how far this treatment would typically transport archaeological material. The presence of fresh condition material in many fluvial gravel contexts, suggest such material may often become quickly incorporated, and thus represent an archaeological sample of relatively tight stratigraphic and spatial provenance. However, the presence of some very rolled material indicates the potential for substantial transport and mixing. Although it has generally been argued over the last 25 years (English Heritage 1991; Cook in Chippindale 1989) that material from disturbed fluvial contexts is of much less value than that from undisturbed, several workers have recently emphasised the potential of disturbed material as a valuable complement to undisturbed material, allowing different issues to be investigated (Hosfield 1999; Wenban-Smith & Bridgland 2001). Predominantly gravelly coarse-grained fluvial deposits may also contain finer-grained clay-silt and sand lenses within which reflect periods of quieter flow and possibly the development of short-lived land-surfaces. Such horizons may contain undisturbed archaeological material. The increased incidence of underwater submergence through the Pleistocene of MADs, compared to their terrestrial equivalents, would probably enhance the chances of preservation of biological material due to the increased anaerobic conditions, although these sediments will of course have gone through previous cycles of exposure and inundation which may have led to the rotting of faunal remains from sediments which are currently submerged.

Marine storm beach deposits have formed in an entirely different way to fluvial gravels, despite a superficial similarity in constituents. Any archaeological material within them may be quite rolled and chronologically mixed by repeated wave action, but is still unlikely to have travelled far since deposition. Storm beaches may also contain horizons of undisturbed material within them and towards their surface, sealed by collapses of the bedrock into which the beach notch is cut.

The glacigenic deposits of the Humber Estuary would have formed in close proximity to the ice-sheet of the last glacial maximum, around the time of the last glacial maximum. This is not a location where human activity is likely to have occured, besides which we know that humans were absent from this region between *c.* 20,000 and 13,000 BP. Furthermore, if there was evidence, then the destructive effect of glaciation and the higher energy of the outwash processes would have severely affected it.

With respect to MADs, it is also necessary to consider the extra effects of:

- marine transgression
- protracted submergence
- marine regression
- repeated cycles of same.

These are clearly complex issues, related to numerous factors including the speed and trajectory of transgression and regression, the gradient of the coastline, local sea-current regimes and underlying geology. Current BGS mapping of the southern North Sea shows a long term history of the accumulation of substantial sheets of sediments from successive stages of the Quaternary (Cameron *et al.* 1992), suggesting that whatever the destructive effects of successive changes in sea-level, they have often not eradicated pre-existing deposits. The rising water-level would favour the preservation of associated organic material, and once buried, it may be more resistant to the effects of subsequent aerial exposure due to subsequent marine regression, enhancing the interpretive potential of any sites discovered.

3.4 Importance

There are several reasons why Palaeolithic archaeological evidence within MADs would be of reasonable or high importance. First, although Palaeolithic archaeological evidence within MADs would generally be disturbed, there exists the potential for undisturbed sites of high importance within river terrace gravels and storm beach deposits. The importance of these sites would be enhanced by the likely preservation of associated biological evidence in MADs, due to their history of submergence, useful for both interpreting behaviour at the site more completely and establishing its date and the environmental and climatic context of occupation more accurately.

Second, disturbed archaeological material within MADs would also be of archaeological value, provided it came from a well-defined context, such as a specific fluvial or storm beach gravel unit. There is debate about how important this type of disturbed evidence is, but there seem good arguments for not discounting it, as a) it provides a sample of material culture from a broader space-time envelope than undisturbed sites, which may help address different questions, and b) even if we are not quite sure what the full potential of this material is, we should be wary of disregarding it as it constitutes the majority of the Lower/Middle Palaeolithic record. As mentioned above several workers have begun to appreciate the potential of disturbed evidence.

Third, MAD sites would relate to early human activity in different landscape contexts to those known from current terrestrial studies.

Fourth, from an international perspective, the investigation of well-dated sites, both disturbed and undisturbed, in the Channel and North Sea, with a wealth of biological and palaeo-environmental evidence, may provide a means of integrating the terrestrial sequences in northern France and Holland better with those from England, as well as with the global Oxygen Isotope framework. This would help in the investigation of hominid material cultural change in these areas, and clarify to what extent these regions had different or related histories of material cultural change.

3.5 Distribution

The most reliable indicator of the distribution of MADs of potentially higher archaeological significance is their correlation with terrestrial deposits of known significance by means of extrapolation of the downstream channel profile. Certain fluvial terrace deposits in the Thames Valley and East Anglia for instance have been proven to be of archaeological significance, and this significance would be likely to be as great or greater in the off-shore correlates due to the enhanced faunal preservation. In the Thames Estuary for instance, mapping has shown a well-developed fluvial terrace system offshore whose oldest member is relatable to the OI Stage 8–6 Taplow/Mucking Gravel of the Thames terrestrial sequence (Bridgland *et al.* 1983). In the lower reaches of the Thames deposits of this age have proven of particular richness at sites such as Crayford (Spurrell 1883 & 1884) and Northfleet (Wenban-Smith 1995).

Within MADs, thin horizons of clays/silts/sands may show up on seismic profiles, and could then be identified as of higher archaeological potential. Clay and silt-rich sediments would, however, be avoided as undesirable MADs, so it would be important to clarify the extent to which these are recognisable during sea-bed development, and the potential for thin unrecognised horizons to a) contain significant evidence and b) be incorporated within extracted MADs. Sand-rich horizons within MADs would not, in contrast, be specifically avoided, and these might also contain less-disturbed archaeological material.

Terrestrial work has also indicated the increased likelihood of archaeological material near valley-side channel banks, so this could also be highlighted as an area of increased archaeological potential in advance of development of sea-bed river terrace deposits.

3.6 Indicators

Occasional discoveries of identifiable Lower and early Middle Palaeolithic evidence such as handaxes or extinct mammalia such as woolly mammoth or elephant may be generally indicative of the presence of undisturbed bodies of sediment containing further similar evidence, and hence of archaeological significance. However, given the possibilities of erosion to have reworked such bodies and redeposited the material in a jumble with material from all periods, with material possibly being transported substantial distances by past or present tidal currents, one should be wary of presuming that significant deposits are present on the basis of stray finds. Over a period of time, a pattern of repeated finds might provide stronger indications of significance, and it is worth exploring what recording mechanisms are in place which might begin to pick up such patterns for the purposes of assessing the archaeological significance of areas of MADs.

Once an MAD has been identified for development, it would be reasonably straightforward to sample it for archaeological evidence by investigating grab samples, either on the spot on the survey vessel, or onshore if the samples are transported back with reliable labelling.

3.7 Impact

Large-scale mapping of sea-bed sediment and MAD extraction areas shows that substantial extraction has taken place in the same general vicinity as sediments identified as of potential Palaeolithic significance, particularly:

- In fluvial gravel terrace systems off East Anglia
- In fluvial gravel terrace systems in the Thames Estuary
- In fluvial gravel terrace systems south of the East Solent
- In the gravels (fluvial terraces or storm beach deposits) off the Sussex coast

In general there is a coincidence between desirable MADs and deposits of some archaeological potential. Terrace systems and storm beach deposits are dominated by sands and gravels potentially containing archaeological material, and sands and gravels are the main target of marine aggregate extraction. Fine clay/silt/sand sediments postulated as occuring within the main fluvial terrace sequences and potentially containing undisturbed horizons would be undesirable as MADs if dominated by clays and silts, but may be extracted if predominantly sand. These are liable to be contained as a sandwich filling between or above more desirable gravel layers, and hence would be subject to destruction by extraction, particularly if predominantly sandy or not picked up by seismic investigations.

4 Late Upper Palaeolithic and Mesolithic

4.1 Formation

Following Bridgland's model, the end of the last glaciation should have been accompanied by mobilisation of sediments, downcutting of river channels, and substantial aggradations in channel bases (Figure 5, phases 1 and 2). This would have led to the formation of substantial bodies of coarse-grained sediments suitable as MADs. However it is uncertain how far offshore these gravel-filled last glacial channels reach. Selby (pers. comm.) has described seismic results indicating that the channel-fills tail off close to the shore, with the empty last glacial channel continuing further offshore, having cut down through earlier gravels, leaving them as valley-side terraces. These last glacial channels would have created the focus of the present day drainage systems, and would have been filled up with alluvial deposits as sea-level rose through the Holocene. MADs interpreted as of fluvial origin have been found off East Anglia, in the Thames Estuary and off the South Coast (*cf.* Table 3). While most of these deposits probably relate to terraces pre-dating the last glacial maximum, some of them are likely to date from the post-glacial phase of fluvial downcutting and aggradation.

A substantial body of glacigenic MADs have been identified in the Humber Estuary. While some of these are probably contemporary with the last glacial maximum, most probably relate to melting and retreat of the ice-sheet accompanying climatic amelioration.

Following this phase of sediment mobilisation and deposition, finer-grained wind-blown silts and sands would have covered the exposed landscape in the period 11,000 to 5,000 while the sea-level was rising and while substantial off-shore areas were still exposed. Ponds and lakes would have formed in depressions, leading to the deposition of clays and silts, and reed beds and peat-bogs would have developed in many locations, sealing the existing landscape. While these finer-grained sediments are of no interest in themselves as MADs, they may have covered desirable MADs sufficiently thinly not to make them inaccessible for extraction. These deposits would have been progressively encroached upon as sea-level rose through the Holocene. In places they would have been substantially destroyed, but in others they may have been sufficiently quietly or rapidly buried to survive relatively unscathed on the current sea-bed.

4.2 Inhabitation

After the last glacial maximum at 18,000 BP, there was a steady rise accompanying climatic amelioration, with sea-level reaching –65m OD by 10,000 BP at the end of the last glaciation, and continuing to rise more and more slowly towards the high sea-level of the present day, reaching –5m OD by 5,000 BP at the end of the Mesolithic (Figure 6; Chappell & Shackleton 1986).

Interpretation of which parts of the off-shore underwater landscape would have been exposed for human settlement by this sea-level history is complicated by having to consider how the current sea-bed topography developed/changed during this period. The greatest changes have been in the central North Sea where the advance and retreat of the last glacial ice has led to the development of the BGS Elements G and H (Table 3), which include the Dogger and Bolders Bank Formations, which now form substantial bodies of sediment northward of East Anglia, but which would not have been present before the last glacial maximum.

The drop of sea-level to –125m OD at the last glacial maximum would have essentially rendered the whole of the southern North Sea and the English Channel dry land, with a substantial drainage network flowing out towards the Atlantic, fed by southward tributaries such as from the Solent region. Once formed in the late last glacial, the Dogger Bank would have been a substantial hilly region in the North Sea plain, and, as sea-level rose in the Holocene, would have remained exposed first as a peninsular and then an island of an extensive archipelago. Coles (1998) suggests that it was only cut off as an island in after *c.* 5,000 BP when sea-level climbed to within 10–12m of its current height, although Jelgersma's (1979) sea-level model would suggest this happened earlier. Thus large areas of the Channel and North Sea would have been dry land for the first half of the period in question (Figure 6), and numerous islands would have remained exposed in the North Sea even at the end of the Mesolithic.

Humans did not recolonise Britain until after 13,000 BP when there is a cluster of dates from both cave and open-air sites associated with Upper Palaeolithic artefacts in the period 12,800–10,300 BP, and corresponding with a (temporary) period of marked climatic amelioration. Following this amelioration, the eventual end of the ice-age at *c.* 10,000 BP was presaged by at least two short-lived returns to cold conditions (the Older Dryas and the Younger Dryas/Loch Lomond Stadial), which may have interrupted human occupation, leading to the lack of continuity in the British archaeological record for the transition from final Upper Palaeolithic to Mesolithic adaptations.

The advent of the Mesolithic was probably not a change of population, but a change of adaptation to a new means of hunting and the new, wooded and watery post-glacial environment. Mesolithic assemblages proliferate across northern Europe in the 10th–9th millennia BP, with the earliest British site being Thatcham III in Berkshire at just before 10,000 BP. At this point in time the sea-level is estimated to have been –65m OD, which would have rendered the bulk of the English Channel and the North Sea dry land. It has been suggested (eg. Clark 1954; Coles 1998) that the North Sea was the heartland of the Early Mesolithic way of life, based on the exploitation of rich coastal regions, and a rich archipelagic environment combining littoral marine and terrestrial resources. Rich sites showing a similar (Maglemosian) cultural tradition have been found on the fringes of the North Sea in both England and Scandinavia.

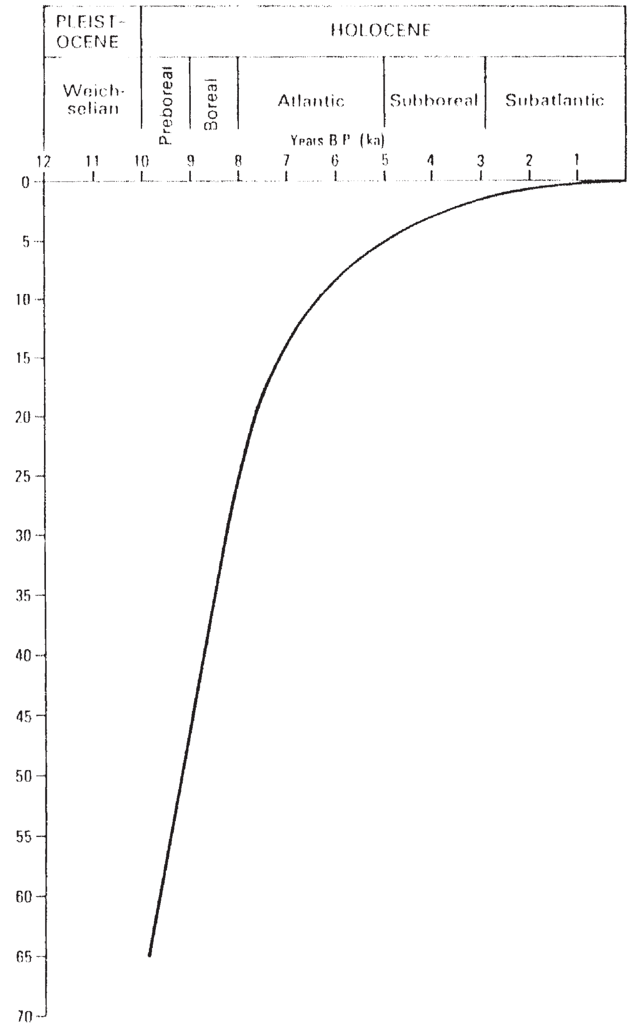

Figure 6. Holocene sea-level rise (Jelgersma 1979)

4.3 Preservation

Two main categories of deposit are relevant to this discussion of the impact by MAD extraction. First, there are MADS themselves, ie. post-last glacial fluvial and glacigenic gravels; and second, there are finer-grained clay, silt and organic-rich deposits thinly developed on the surface of desirable MADs. The fluvial gravels will have formed at a period when there was no human occupation in the area, and so will only contain substantially derived archaeological material from earlier periods. Similarly, the glacigenic MADs have been formed in the immediate vicinity of the ice front of the last glacial maximum as outwash deposits. This is also a location without human inhabitation, and so such deposits are of little or no archaeological potential in themselves.

Fine-grained aeolian, waterlain and/or organic late- and post-glacial deposits are, however, liable to have accumulated on the whole of the post-glacial landscape in the period between the first climatic amelioration at *c.* 13,000 BP and the subsequent rise of sea-level, which for instance only reached –20m OD at 8,000 BP (Figure 6). These deposits are likely to have covered MADs in varying thickness according to location and landscape context, and in contrast, these would contain exceptionally undisturbed archaeological remains with the likelihood of good preservation of biological evidence. They would also, however, have been more vulnerable to the affects of marine transgression, so might sometimes have been destroyed altogether and their evidence scattered far and wider, or left as a winnowed lag deposits. There is also a question mark over the extent to which such sediments have been affected by other sea industries as fishing. They are likely sometimes, however, to still be preserved, and the recognition of such sediments must be a priority.

4.4 Importance

Archaeological evidence from undisturbed deposits of this period overlying MADs would be of national or international importance for several reasons:

- High likelihood of undisturbed sites with good organic preservation.
- Related to post-glacial re-colonisation of Britain.
- Related to transition from Upper Palaeolithic to Mesolithic adaptation.
- Involve investigation of human adaptation in lower-lying parts of palaeo-landscape, particularly in the postulated North Sea heartland of the Early Mesolithic adaptation.

4.5 Distribution

The most likely sorts of deposit to occur in this period with significant archaeological evidence are:

- Estuarine/alluvial clay and silt-rich floodplains and peaty horizons.
- Terrestrial lacustrine/littoral peats and clays/silts.
- Late glacial and early post-glacial loessic sediments

Fine-grained alluvial floodplains and estuarine peats and silts of this period would be associated with the upper levels of palaeo-drainage systems. These might be expected to be found in the networks of infilled palaeovalleys which occur extensively in the English Channel and in the mouth of the Thames Estuary. Peats and silts might also be found in any of the flatter areas which occur off the British coast, and which would have been inundated fairly gently, such as the Bolders/Dogger Bank region, and the strip of land along the south coast between Exeter and Beachy Head. Momber (2000) for instance has identified peat associated with a buried landsurface in the western Solent, off the Isle of Wight. Peat and an antler harpoon have also been recovered from the Leman Bank, and also the Brown Bank (Coles 1998). The presence of early Holocene peats on top of linear bank features such as the Leman Bank shows that at least the surfaces of these features are intact since that time, even if the trenches between may represent later erosion.

Loessic sediments could have accumulated on any exposed surface, although they would have tended to accumulate more rapidly in sheltered hollows and the lees of any cliffs or scarps. These of course would also have been favoured spots for human occupation, so there may have been a beneficial coincidence of process and activity leading to creation of the archaeological record. On comparative dry land locations, the gravels of MAD-type deposits have proved a desirable occupation location due to their good local drainage, so MADs may also have been a focus for occupation when they were exposed.

4.6 Indicators

For the later evidence contained within the most superficial deposits such as peats, stray finds are a good indicator of the location and presence of potentially significant horizons. An antler harpoon point was recovered from the Lemans Bank in the 1930s at a depth of *c.* 20m below OD, and subsequent investigations recovered peat from the same location dating to *c.* 8,500 BP. Peat has also been recovered from depths of nearer 40m below OD north of the Dover Straits (Coles 1998). As mentioned above, Momber (2000) has identified peat and alluvium containing Mesolithic archaeological material in the western Solent. Peats have also been studied within intertidal zones such as the Thames Estuary (Haggart 1995) and the Severn Estuary (Bell *et al.* 2000), and it seems likely that similar evidence continues off-shore into deeper waters, although is less accessible for study.

Late Upper Palaeolithic material has been recovered from several open-air coastal sites, from thin loessic sands/silts overlying earlier Pleistocene solifluction or fluvial deposits and sealed by later Holocene peats or alluvium, for instance at Hengistbury Head on the Dorset coast and Titchwell on the Norfolk coast

(Barton 1992). This emphasises the potential for similar material to be present off-shore on the sea-bed.

There is generally a current lack of sufficiently detailed and systematic investigation of the superficial sediments of the sea-bed to establish the most likely locations of preserved sediments of this nature. A proxy model could potentially be based on the topography of the Pleistocene surface, but it may be simpler and more effective to carry out direct field investigations.

4.7 Impact

In general, the type of deposit of maximum potential for this period – thin layers of fine-grained loessic or lacustrine–littoral sediment – may occur on the surface of any MADs. Given the difficulties of predicting whether this is the case for specific areas or bodies of MAD, it cannot be said whether any impact has in fact occurred or is imminent at any specific sea-bed location. However there is clearly a high potential for impact, and it is almost certain that some part of the currently identified MAD resource contains on its surface archaeological evidence of national or international significance.

A particular potential future concern over the impact of MAD extraction on such deposits is the extent to which undesirable fine-grained clay and silt-rich overburden might be deliberately removed to expose underlying deposits for extraction. This practice is not currently prevalent, but it is easy to imagine that it might become so as more accessible MAD resources become scarcer. This would obviously have a major impact upon potentially significant archaeological deposits.

Given the core significance in the Early Holocene of the North Sea plain as the cradle of Mesolithic adaptation, and the presence of highly significant sites on its margins such as Star Carr, N. Yorkshire (Clark 1954) in England and Maglemose in Denmark, one might *a priori* identify the MADs in the North Sea, and particularly those off the Humber Estuary as of higher potential significance.

5 Conclusions

5.1 Lower, Middle and Early Upper Palaeolithic

Presence

Evidence from the Lower and Middle Palaeolithic periods is definitely present within some, if not many, areas of MAD:

- off East Anglia;
- in the Thames Estuary;
- off the southern coastline, particularly in the eastern Solent area.

Evidence from the early Upper Palaeolithic is unlikely to be present within MADs.

Nature

The Lower/Middle Palaeolithic evidence within MADs:

- is probably mostly disturbed and transported by fluvial processes;
- may have good preservation of biological evidence;
- may contain undisturbed horizons within it, either within sandy horizons liable to be extracted as part of the desirable MAD, or within thin clay and silt-rich horizons liable to be extracted accidentally.

Significance

The Lower/Middle Palaeolithic evidence within MADs is of significance for the following reasons:

- The disturbed material is of value for providing time and space averaged samples;
- It provides a link between British and continental evidence;
- There is a slightly increased potential of biological evidence;
- There is some, albeit low, potential for undisturbed sites with enhanced biological preservation;
- Any evidence will provide information on settlement and colonisation in different landscape contexts than hitherto investigated in terrestrial contexts.

Impact

Lower and Middle Palaeolithic material is very likely present within fluvial terrace gravels currently being exploited, or licensed for future development, as MADs:

- off East Anglia;
- in the Thames Estuary;
- off the southern coastline, particularly in the areas south-east and west of the Isle of Wight, and in new areas in the eastern English Channel.

Given the large scale of current licensing and future extraction predictions (Hamblin *et al.* 1992; Cameron *et al.* 1992), MAD dredging will lead to a significant impact upon the associated Palaeolithic archaeological resource.

5.2 Final Palaeolithic and Mesolithic

Presence

Evidence from the final (Late Upper) Palaeolithic and Mesolithic is unlikely within any MADs. It is, however, likely to be present within thin deposits of sands, silts and/or organic sediments overlying MADs.

There is no information currently available to identify which MADs are more likely to have such evidence on their surface, although it is possible that such evidence is widespread and common.

Nature
Where such deposits are present, they may contain:

- disturbed archaeological material, affected by marine transgressive process;
- undisturbed archaeological horizons.

Excellent preservation of biological evidence is likely for both disturbed and undisturbed material.

Significance
Archaeological evidence from undisturbed deposits of this period overlying MADs would be of national or international importance for several reasons:

- High likelihood of undisturbed sites with good organic preservation;
- Related to post-glacial re-colonisation of Britain;
- Related to transition from Upper Palaeolithic to Mesolithic adaptation;
- Involve investigation of human adaptation in lower-lying parts of palaeo-landscape, particularly in the postulated North Sea heartland of the Early Mesolithic adaptation.

Impact
Such deposits may occur as a thin overburden on the surface of any MADs and little investigation has been carried out to investigate the presence and extent of archaeological evidence overlying MADs.

Such sediments could occur on any MAD, and it is likely that some part of the currently identified MAD resource contains on its surface archaeological evidence of national or international significance.

Given the importance of the North Sea as a focus of Mesolithic occupation, MAD extraction in this area may be having a greater archaeological impact than elsewhere.

5.3 Consequences

MAD extraction affects deposits beyond the reach of normal terrestrial archaeological research. Uncontrolled, and unmitigated, extraction would clearly have a detrimental effect upon the archaeological resource, by destroying potentially significant parts of it without any record. However, if effective means of identifying deposits of archaeological significance and then studying them can be developed, then the overall consequence of MAD extraction would be beneficial.

For the earlier, Palaeolithic period, the disturbed nature of evidence means that valid mitigation can be achieved by sampling a proportion of any particular MAD body, so it may not yet be too late to start recovering information even from MADs which have already undergone substantial extraction. There is a low-moderate chance of some MADs containing undisturbed Palaeolithic horizons. If these were present, and destroyed, this would be a major loss considering the potentially excellent biological preservation of such horizons in view of their underwater context.

For the Late Upper Palaeolithic and Mesolithic periods, the consequences of unrecorded extraction are probably more adverse, in that evidence from this period may well be more widespread, and where present, is more likely to be undisturbed with excellent biological preservation. As for the evidence from earlier periods, the consequences of finding a way of identifying and recording archaeological evidence in advance of extraction would be hugely beneficial, as otherwise inaccessible material with unmatched biological preservation would be recovered. Given that such material will be on or close to the surface of MADs, such an exercise may not be too impractical.

5.4 Problems

This paper constitutes a general review of the potential for Palaeolithic and Mesolithic archaeological remains in and/or on MADs. The conclusion is that they are likely to be present in several or many MADs, and may well on occasion be highly significant. There are numerous problems to address in moving beyond this general conclusion, to consider how the presence, nature and significance of such archaeological remains can be predicted or identified, and then studied, in advance of or in conjunction with extraction.

Particular problems include:

- identifying the nature and dates of MADs;
- the gross scale of sea-bed sediment mapping in relation to the potentially fine scale at which archaeological remains may be present;
- clarifying the extent to which sand-rich deposits are accepted as desirable MADs, and the amount of clay–silt presence which negates their potential as MADs; if sand bodies with occasional silty laminae are acceptable as MADs, then this poses a significant threat to undisturbed archaeological evidence;
- the difficulties of predicting the presence of significant archaeological remains in light of the problems of reconstructing palaeobathymetry, due to the uncertain impact of:
  - marine transgressions, regressions and sub-marine processes

  – isostatic effects
  – eustatic effects
  – tectonic movement;

- practical difficulties of evaluating and studying archaeological evidence on the sea-bed;
- establishing the impact, both previous and future, of other marine industries upon the sea-bed archaeological resource;
- the less well-developed curatorial framework for non-wreck off-shore archaeological remains.

5.5 The Way Forward

The conclusion of this preliminary review is that MADs do in principle have the potential to contain significant archaeological evidence of both Palaeolithic and Mesolithic periods.

More attention should now be paid to:

- means of identifying whether specific MADs earmarked for extraction contain significant evidence;
- how can that evidence be recorded in advance of, or in conjunction with, extraction.

Preliminary thoughts on productive steps include:

- a pilot exercise to investigate the presence of archaeological evidence in MADs, whether by sampling of undeveloped deposits, or by investigation of samples already retained on dry land from previous sampling exercises;
- a review and synthesis of existing records for relevant off-shore data, including SMR and Royal Commission records, and stray finds in museum collections and private hands;
- formalisation of the curatorial structure in relation to archaeological aspects of sea-bed development and the licensing of extraction areas;
- assessment of the impact, both previous and future, of other marine sectors such as fisheries and cable laying, and consideration over whether any such impact requires assessment and mitigation in relation to the historic environment.

References

Aldhouse-Green, S. & Pettitt, P. 1998. Paviland Cave: contextualising the 'Red Lady'. *Antiquity* 72: 756–772.

Barton, R.N.E. (ed.). 1992. *Hengistbury Head, Dorset, Volume 2: The Late Upper Palaeolithic & Early Mesolithic Sites*. Monograph No. 34. Oxford University Committee for Archaeology, Oxford.

Bell, M., Caseldine, A. & Neumann, H. (eds). 2000. *Prehistoric Intertidal Archaeology in the Severn Estuary.* CBA Research Report 120. Council for British Archaeology, York.

Bridgland, D.R. 1994. *Quaternary of the Thames.* Chapman & Hall, London.

Bridgland, D.R. 2001. The Pleistocene evolution and Palaeolithic occupation of the Solent River. In F.F. Wenban-Smith & R.T. Hosfield (eds), *Palaeolithic Archaeology of the Solent River*. Lithic Studies Society Occasional Paper 7. Lithic Studies Society, London.

Bridgland, D.R., D'Olier, B., Gibbard, P.L. & Roe, H.M. 1993. Correlation of Thames terrace deposits between the Lower Thames, eastern Essex and the submerged offshore continuation of the Thames–Medway valley. *Proceedings of the Geologists Association* 104: 51–57.

Callow, P. & Cornford, J.M. (eds). 1986. *La Cotte de St. Brelade 1961–1978: Excavations by C.B.M. McBurney*. Geo Books, Norwich.

Cameron, T.D.J., Crosby, A., Balson, P.S., Jeffery, D.H., Lott, G.K., Bulat, J. & Harrison, D.J. 1992. *The Geology of the Southern North Sea*. HMSO, London.

Chappell, J. & Shackleton, N.J. 1986. Oxygen isotopes and sea-level. *Nature* 324: 137–140.

Chippindale, C. 1989. Editorial. *Antiquity* 63: 413–416.

Clark, J.G.D. 1954. *Excavations at Star Carr.* Cambridge University Press, Cambridge.

Coles, B.J. 1998. Doggerland: a speculative survey. *Proceedings of the Prehistoric Society* 64: 45–81.

Dyer, K.R. 1975. The buried channels of the 'Solent River', southern England. *Proceedings of the Geologists Association* 86: 239–246.

English Heritage. 1991. *Exploring our Past: Strategies for the Archaeology of England.* HBMCE, London.

Funnell, B.M. 1995. Global sea-level and the (pen-)insularity of late Cenozoic Britain. In R.C. Preece (ed.), *Island Britain: a Quaternary Perspective*: 3–13. Geological Society Special Publication No. 96. The Geological Society, London.

Hosfield, R.T. 1999. *The Palaeolithic of the Hampshire Basin*. BAR British Series 286. Hadrian Books, Oxford.

Gamble, C.S. (ed.). 1999. *Research Frameworks for the Palaeolithic and Mesolithic of Britain and Ireland.* The Prehistoric Society, London.

Hamblin, R.J.O., Crosby, A., Balson, P.S., Jones, S.M., Chadwick, R.A., Penn, I.E. & Arthur, M.J. 1992. *The Geology of the English Channel.* HMSO, London.

Haggart, B.A. 1995. A re-examination of some data relating to Holocene sea-level changes in the Thames Estuary. In D.R. Bridgland, P. Allen & B.A. Haggart (eds), *The Quaternary of the Lower Reaches of the Thames*: Field Guide: 329–337. Quaternary Research Association, Durham.

Imbrie, J., Hays, J.D., Martinson, D.G., McIntyre, A.C., Mix, A.C., Morley, J.J., Pisias, N.G., Prell, W.L., & Shackleton, N.J. 1984. The orbital theory of Pleistocene climate: support for a revised chronology of the marine $\delta^{18}O$ record. In A.L. Berger, J. Imbrie, J.D. Hays, G.J. Kukla & B. Saltzman (eds), *Milankovitch and Climate*: 269–306. Reidel, Dordrecht.

Jelgersma, S. 1979. Sea-level changes in the North Sea basin. In E. Oele, R.T.E. Schüttenhelm & A.J. Wiggers (eds), *The Quaternary History of the North Sea*: 233–248. Acta Universitatis Upsaliensis: Symposium Universitatis Upsaliensis Annum Quingentesimum Celebrantis 2.

Long, A.J. & Tooley, M.J. 1995. Holocene sea-level and crustal movements in Hampshire and southeast England, United Kingdom. *Journal of Coastal Research Special Issue No. 17: Holocene Cycles: Climate, Sea Levels and Sedimentation*: 299–310.

Momber, G. 2000. Drowned and deserted: a submerged prehistoric landscape in the Solent, England. *International Journal of Nautical Archaeology* 29: 86–99.

Roberts, M.B. & Parfitt, S.A. (eds). 1999. *Boxgrove: a Middle Pleistocene Hominid Site*. English Heritage, London.

Roebroeks, W., Conard, N.J. & van Kolfschoten, T. 1992. Dense forests, cold steppes, and the Palaeolithic settlement of Northern Europe. *Current Anthropology* 33: 551–586.

Roebroeks, W. & Tuffreau, A. 1999. Palaeoenvironment and settlement patterns of the northwest European Middle Palaeolithic. In W. Roebroeks & C. Gamble (eds), *The Middle Palaeolithic Occupation of Europe*: 121–138.

Spurrell, F.C.J. 1883. Palaeolithic implements found in West Kent. *Archaeologia Cantiana* 15: 89–103.

Spurrell, F.C.J. 1884. On some Palaeolithic knapping tools and modes of using them. *Journal of the Anthropological Institute* 13: 109–118.

Stuart, A.J. 1982. *Pleistocene Vertebrates in the British Isles*. Longman, London.

Wenban-Smith, F.F. 1995. The Ebbsfleet Valley, Northfleet (Baker's Hole). In D.R. Bridgland, P. Allen & B.A. Haggart (eds), *The Quaternary of the Lower Reaches of the Thames*: Field Guide: 147–164. Quaternary Research Association, Durham.

Wenban-Smith, F.F. & Bridgland, D.R. 2001. Palaeolithic archaeology at the Swan Valley Community School, Swanscombe, Kent. *Proceedings of the Prehistoric Society* 67, 218–260.

The British Marine Aggregate Producers Association (BMAPA), as part of its commitment to ensuring the environmental sustainability of marine aggregates extraction, initiated a project with the Royal Commission on the Historical Monuments of England (RCHME, now English Heritage) to ensure effective and practical consideration of the historic environment in the licensing of marine aggregate extraction.

This report is the result of one element of the project. It constitutes an initial review of the potential for the presence of Palaeolithic and Mesolithic archaeological remains in sea-bed sediments suitable for use as aggregates. The emphasis is on a general consideration of the nature and significance of the archaeological evidence liable to be present in the types of sediment exploited as marine aggregate deposits (MADS). The conclusion is that Palaeolithic and Mesolithic remains are likely to be present in and/or on several or many MADs and may well, on occasion, be highly significant.

Palaeolithic
Disturbed Lower and Middle Palaeolithic archaeological evidence is likely to be present within many MADs of Pleistocene fluvial origin. Undisturbed horizons may also, on occasion, be present within these deposits. In general this evidence would be of similar importance to that on land, possibly with an increased potential of good biological preservation

Final Palaeolithic and Mesolithic
Both disturbed and undisturbed final Palaeolithic and Mesolithic evidence with exceptional biological preservation may be present in thin layers of fine-grained deposits (clays, silts, sands and organic-rich sediments) on the surface of many MADs. Undisturbed evidence of this period from an underwater context is likely to be of national or international significance in view of the preservation of organic evidence, and the potential for investigation of the post-glacial recolonisation of Britain and the North Sea based Mesolithic adaptation.

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