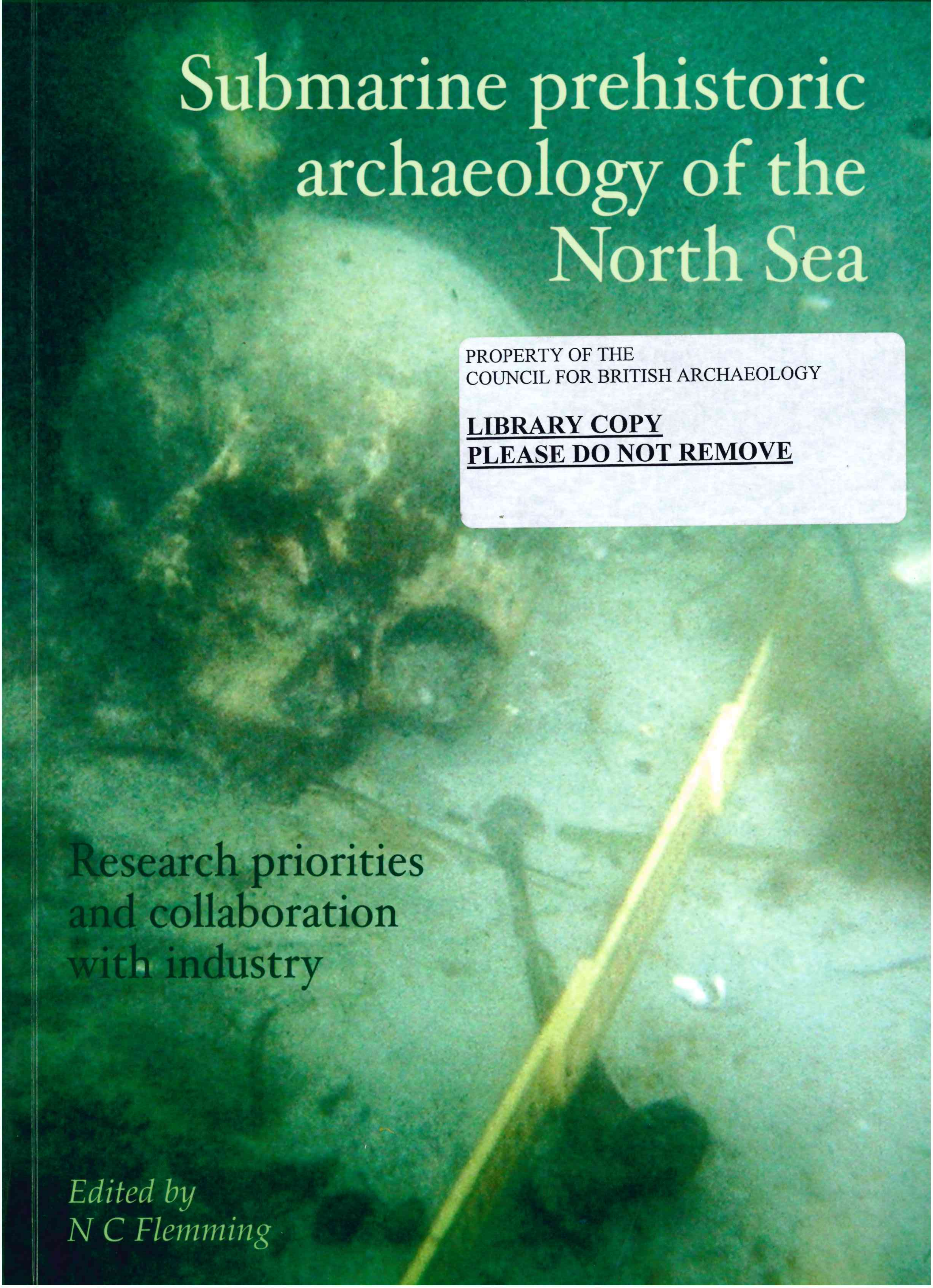
Research Report 141

Submarine prehistoric archaeology of the North Sea



Research priorities and collaboration with industry

Edited by
N C Flemming

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Back cover: computer-generated perspective of the British Isles colour-coded to show the sea level and topography at 22,000 BP (© Justin Dix:University of Southampton)

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Summaries

On 29 May 2003 archaeologists from five countries bordering the North Sea attended a workshop hosted in London by English Heritage on the subject of *North Sea submarine prehistory and relations with industry*. This book includes the papers presented at that workshop, together with a summary of the discussion and conclusions. Participants came from Norway, Denmark, Germany, the Netherlands, and the UK. The purpose of the workshop was to bring together archaeologists who have worked on submerged prehistoric sites around the North Sea Basin, or in immediately adjacent waters in the Baltic and English Channel, to analyse the potential for prehistoric archaeology research on the floor of the North Sea, and to plan the best way to cooperate on future research and protection of prehistoric sites on the sea floor.

The reports describe a range of submerged sites, and artefacts, occupied or used during the late Pleistocene and early Holocene periods of glacially controlled, low sea level when large areas of the north-west European Continental Shelf were dry land. They show that Palaeolithic, Mesolithic, and Neolithic peoples created settlements on the contemporaneous coastlines at periods of low sea level, and probably in the hinterlands of the central North Sea, sometimes known as Doggerland.

The age of most known submerged sites is in the range of 8000–5000 years old, but older submerged sites have been discovered outside the North Sea region. The topics requiring study include the Ice Age climate cycles in the area, drainage patterns, and the spatial distribution of river valleys and palaeo-shorelines, soil types, sedimentology, and formation of wetland deposits of peat and drowned forests. The recovery of fossil bones from the seabed permits a detailed palaeontological study of the terrestrial mammalian fauna and marine mammals which provided a food base for humans and possibly earlier hominids. This is in addition to the search for and study of the archaeological sites themselves within the context of the submerged landscape.

The participants reviewed the contribution which could by made to this research by using the technology developed by modern offshore industries, and the best way to work with industry in order to maximise the information gained by archaeologists. National and European legislation requires the offshore prehistoric cultural heritage to be protected, and collaboration with the offshore oil and gas industry, aggregates dredging, civil engineering, windfarm construction, and the fishing industry, provides the opportunity to discover more about the submerged ancient landscape, while ensuring that damage is minimised.

Résumé

Le 29 mai 2003, des archéologues de cinq pays côtiers de la mer du Nord participèrent à un atelier tenu à Londres par English Heritage, dont le sujet était «*Préhistoire sous-marine de la mer du Nord et relations avec l'industrie*». Le présent livre contient les communications présentées lors de cet atelier, ainsi qu'un résumé des discussions et des conclusions qui en ont été tirées. Les participants venaient de Norvège, du Danemark, d'Allemagne, des Pays-Bas et du Royaume-Uni. Le but de l'atelier était de réunir des archéologues qui avaient travaillé sur des sites préhistoriques submergés autour du bassin de la mer du Nord, ou dans les eaux immédiatement adjacentes de la Baltique et de la Manche, afin d'analyser le potentiel de la recherche archéologique préhistorique au fond de la mer du Nord et de planifier la meilleure manière de coopérer sur la recherche future ainsi que sur la protection des sites préhistoriques au fond de la mer.

Les rapports décrivent divers sites submergés et objets fabriqués, occupés ou utilisés à la fin du pléistocène et au début de l'holocène, ères durant lesquelles le niveau de la mer était bas à cause de la glaciation et de grandes parties de la plateforme continentale du nord-ouest de l'Europe étaient des terres sèches. Ils montrent que les populations du paléolithique, du mésolithique et du néolithique avaient fondé des peuplements sur les côtes contemporaines lorsque le niveau de la mer était bas, et probablement aussi dans l'arrière-pays du centre de la mer du Nord, parfois appelé *Doggerland*.

L'âge de la plupart des sites submergés connus se situe entre 8000 et 5000 années, mais des sites submergés plus anciens ont été découverts hors de la région de la mer du Nord. Au nombre des sujets devant être étudiés se trouvent les cycles climatiques de la période glaciaire dans la région, les systèmes hydrographiques fluviaux, et la répartition spatiale des vallées de rivières et des paléorivages, les types de sols, la sédimentologie, et la formation des dépôts de tourbe des terres humides et des forêts submergées. La récupération d'ossements fossiles du fond de la mer permet de faire une étude paléontologique détaillée de la faune mammalienne terrestre et des mammifères marins qui constituaient l'alimentation de base des êtres humains et peut-être aussi des hominidés qui les ont précédés. Tout ceci s'ajoute à

la recherche des sites archéologiques eux-mêmes et à leur étude dans le contexte du paysage submergé.

Les participants ont fait le bilan de l'apport qui pourrait être fait à cette recherche par le biais de la technologie développée par les industries offshore modernes, et de la meilleure manière de collaborer avec l'industrie afin de maximiser l'information acquise par les archéologues. Les lois nationales et européennes exigent que soit protégé le patrimoine culturel préhistorique offshore, et une collaboration avec les industries offshore du pétrole et du gaz, le dragage d'agrégats, le génie civil, la construction de parcs d'éoliennes, et l'industrie de la pêche, offre la possibilité de découvrir un complément de données concernant le paysage ancien submergé, tout en assurant la minimisation des dégâts.

Zusammenfassung

Archäologen aus fünf Ländern, die an der Nordsee angrenzen, nahmen am 29. Mai 2003 an einem von „English Heritage" (das englische Denkmalpflegeamt) veranstalteten Arbeitskreis teil, mit dem Thema „*Prähistorische Unterwasserarchäologie und Beziehungen zur Industrie*". In diesem Buch sind die Vorträge dieses Arbeitskreises gesammelt und die Diskussionen und Schlußfolgerungen zusammengefasst. Teilnehmer kamen aus Norwegen, Dänemark, Deutschland, den Niederlanden und Großbritannien. Zweck dieses Arbeitskreises war, Archäologen zusammenzubringen, die an prähistorischen Unterwasserfundorten in der Nordsee, oder in direkt angrenzenden Gewässern wie der Ostsee oder dem Ärmelkanal tätig sind, das Potential für prähistorische Forschungsarbeiten auf dem Meeresgrund der Nordsee zu analysieren und den besten Weg zu finden, um die Zusammenarbeit an zukünftigen Forschungsprojekten zu fördern und das Kulturerbe des Meeresgrundes zu schützen.

Die Abhandlungen beschreiben eine Vielfalt von Unterwasserfundorten und Fundgegenstände, die während des späten Pleistozän oder frühem Holozän bewohnt oder benutzt worden sind, einer Zeit als der Meeresspiegel aufgrund der Eiszeiten niedrig war und ein Großteil des nordwestlichen Europäischen Kontinentalschelfes trockenes Land war. Aus diesen Fundorten wird erkenntlich, daß während Perioden niedrigen Meeresspiegels Paläolithische, Mesolithische und Neolithische Völker Siedlungen schufen, die entlang dem damaligen Küstenverlauf und wahrscheinlich auch im Umland der heutigen zentralen Nordsee lagen, einem Gebiet daß mitunter auch als *Doggerland* bekannt ist.

Die meisten dieser Unterwasserfundorte wurden auf 8000–5000 Jahre alt datiert, ausserhalb der Nordseeregion sind auch ältere Unterwasserfundorte bekannt. Themen für zukünftige Forschungsarbeiten umfassen unter anderem die genauere Untersuchung von Eiszeitlichen Zyklen in diesem Gebiet, der Verlauf von Drainagekanälen, die geographische Verteilung von Flußtälern und Küstenverläufen, Bodentypen, Sedimentologie und die Bildung von Feuchtgebietsablagerungen wie Torf und versunkene Wälder. Die Bergung von Knochenfunden aus dem Meeresgrund erlaubt detaillierte paläotologische Studien von Land- und Meeressäugetieren, die die Nahrungsgrundlage für die Menschen und vorausgegangen Hominidae schufen. Diese Forschungsthemen sollen die Suche nach und Studie von existierenden archäologischen Fundorten im Rahmen der umliegenden versunkenen Landschaft ergänzen.

Die Teilnehmer untersuchten, welchen Beitrag die Technologie der Hochseeindustrie zu dieser Forschung leisten kann. Es sollen Wege eröffnet werden, um in Zusammenarbeit mit der Industrie das Archäologische Wissen zu erweitern. Nationale und Europaweite Gesetze sollen ermöglichen, daß das prähistorische Kulturgut der Hochsee geschützt wird. Die Zusammenarbeit mit Hochseeindustrien wie Öl und Gas, Aggregatgewinnung, Hoch- und Tiefbau, Windparkkonstruktion und Fischfang eröffnet Chancen mehr über die versunkene historische Landschaft zu erforschen und gleichzeitig Schäden minimal zu halten.

Preface

It was a strange anomaly that, until recently, the Government's agency and adviser on the historic environment, English Heritage, was not responsible for English maritime archaeology. This was resolved with the passing of the National Heritage Act (2002) which extended our remit to include archaeological sites of all types from the low-water line out to the 12 mile limit around England. Our initial policy on maritime archaeology – which details our approach to the management, preservation and protection of marine archaeology in the territorial waters adjacent to England – acknowledged that the sea contains an immense wealth of historical evidence. Because Britain is a group of off-shore islands, and once the centre of a world empire, we potentially have a historic resource without equal, in terms of quantity and diversity of wrecks and sites. To most people maritime archaeology means wrecks, spectacular time capsules like the *Mary Rose*. Less appreciated are the extensive prehistoric landscapes – submerged as Britain was separated from mainland Europe by rising sea levels 8 millennia ago. In addition to the vast number of wrecks, the sea and the shore also preserve the installations of harbours, industry, transport, fishing and defence – reflecting England's history as a major naval, mercantile, industrial and imperial power.

In contrast to this great potential there is currently limited understanding of the character of the maritime archaeological resource, its distribution, its state of preservation or the threats to its continuing survival. English Heritage recognises that studies designed to improve our knowledge of drowned coastal landscapes and palaeo-environments are essential. Consequently, it was timely that shortly after taking over our new responsibilities, we were able to liaise with Dr Nic Flemming, author of a pioneering consultation document on the potential for submerged archaeology in the Department for Trade and Industry's SEA Area 3, in order to promote initiatives such as his Submerged Prehistory Workshop.

Submerged landscapes are an enormous and under-exploited archaeological resource. In addition to preserving, literally, the footsteps of prehistoric people and animals they can allow us to calculate the nature, scale and pace of coastal change. They are an essential component in a 'seamless' approach to terrestrial, coastal and maritime research. To manage and conserve these resources we need a constructive framework for development-led archaeology.

English Heritage is pleased to have been able to assist people, with an interest in North Sea environmental management, North Sea archaeology and submarine prehistory in other parts of the world, to come together to discuss their mutual interests and share their experience. I found the workshop a genuinely exciting and stimulating occasion and I am delighted that this publication will now carry the debate to a wider audience.

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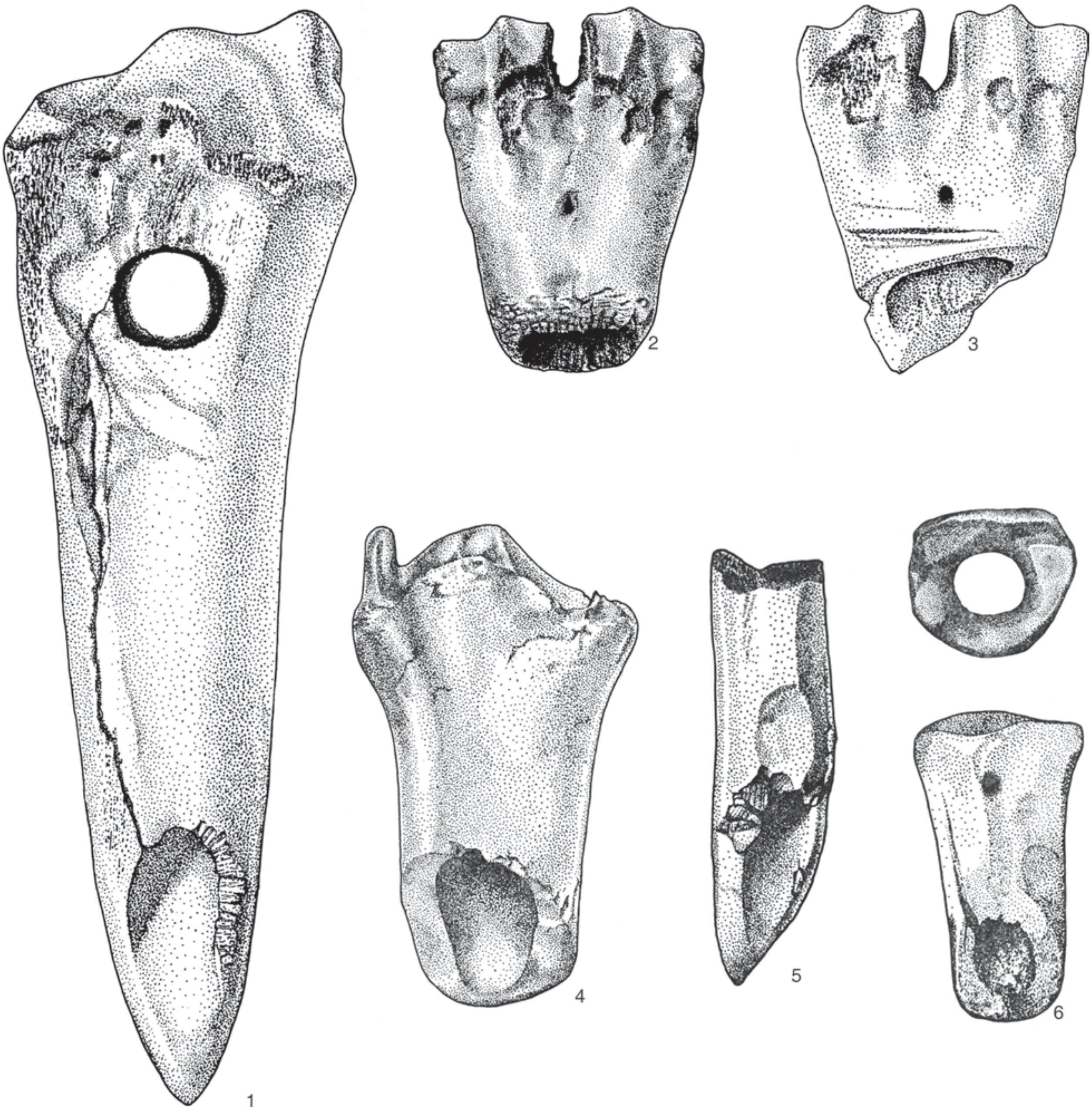
9 September 2004

Section 1 The scope and importance of Continental Shelf prehistory



Bone implements discovered at the Brown Bank, North Sea

1 The wider significance of submerged archaeological sites and their relevance to world prehistory *by Geoff Bailey*

Abstract

This paper addresses the history of scepticism that exists in the wider archaeological community about the value of underwater prehistoric archaeology, and the need to articulate the intellectual problems that justify underwater research. Four preconceptions inform that scepticism: (a) that underwater archaeological remains have not been preserved or are too difficult and costly to retrieve; (b) that in any case they are unlikely to provide information that could not be more easily obtained on land; (c) that coastal settlement and marine palaeoeconomies are marginal to the main patterns of world prehistory, a belief reinforced by 19th-century ethnographic accounts of coastal societies; and (d) that the search for underwater civilisations advocated by amateur enthusiasts is a further symptom of a marginal field of study. In this paper I argue that coastal environments have always been advantageous to prehistoric populations and played a central rather than a marginal role in human development, that underwater archaeology is no more difficult or more subject to problems of differential visibility, loss and destruction than archaeology on dry land, and that underwater work, in consequence, is a necessity rather than an optional luxury if we are properly to understand some of the most important developments in world prehistory.

Introduction

The community of individuals and institutions interested in the ancient land surfaces and archaeology now submerged on the sea floor is a wide one that brings together many different disciplines, nationalities, and interest groups. However, it is important for us to recognise that, at least on the archaeological side, we are part of a much larger community which in general is far from convinced of the virtues of investigating submerged prehistoric archaeology, inclined to regard it as the playground of diving enthusiasts, or an extremely costly enterprise with very uncertain rewards. This climate of scepticism has a long and diverse history, and it is important that we understand something of that history if we are better to address the doubts of the sceptics.

It is also important that we place our interests in the North Sea and the Baltic within a larger-scale international perspective and indeed a global one, because it is at this larger scale that the big questions of cultural transformation and human development considered to be of greatest importance by archaeologists are often posed.

At the outset it may be useful to distinguish two sorts of archaeologically relevant information obtainable from underwater, even at the risk of making a rather arbitrary division. First there is the potential information about the submerged land and the archaeology associated with the use of that 'landscape'. In effect we are talking here about an extension of terrestrial archaeology to examine the ways in which prehistoric people occupied land that is now submerged. A second type of information has to do with the use of early coastlines and the long-term history of human use of aquatic and marine resources, which we might perhaps characterise as the long-term history of the human 'seascape'.

The first theme has been well explored in a number of ways, notably in Bryony Coles' (1998) discussion of the North Sea. It is also certainly apparent to many of us who have engaged in studies of Palaeolithic archaeology on dry land elsewhere that what we are looking at is a truncated fragment of the total picture, and that our results point increasingly to the now submerged portion of the Quaternary landscape as a critical missing part of our regional reconstructions (cf Bailey 1997). I take it as axiomatic that analysing the changing palaeogeographical configuration of land masses and terrestrial environments associated with sea-level change is fundamental to our understanding of Palaeolithic and Mesolithic ecological and cultural dynamics. However, I want to concentrate here on the second theme, because I believe the role of coastlines has been seriously underestimated in the conventional view of human development, and that this is a theme where underwater research could have a big impact. I therefore want to examine, briefly, two issues. First I want to examine why coastlines and the use of marine resources have been discounted in the conventional archaeological accounts of world prehistory. Second I want to make the argument for why coastlines ought to be accorded much greater significance than has been the case until now.

Why have prehistoric coastlines been discounted?

Absence of evidence due to sea-level change

Undoubtedly one of the most potent factors has been the extreme rarity of coastal sites or evidence of marine activity before the postglacial period. In European terms coastal sites such as shell middens or other sorts of coastal settlements with evidence of maritime activities such as fishing or sea-mammal hunting are typically associated with the Mesolithic period, and even here only in abundance from about 6000 BP onwards. A similar pattern can be found elsewhere in the world. Shell mounds, often of great size like the Ertebølle shell mounds of southern Scandinavia, are found in their tens of thousands around the coastlines of the world after about 6000 years ago. Before that date they are rare. Occasional sites or groups of sites with quite substantial marine indicators, though scarcely on the scale of later shell middens, are found dating from 12,000 to 6000 years ago, notably in the coastal caves of northern Spain, the Mediterranean basin and South Africa, on the coast of California in both cave and open-air locations (Erlandson 2001), and at the Natsushima oyster mound of Tokyo Bay in Japan (Sugihara and Serizawa 1957). Before 12,000 BP there is almost nothing except a few Upper Palaeolithic limpet shells in some European coastal caves, until we reach back to the previous period of high sea levels associated with the last interglacial (Fig 1.1).

Compared to the long sweep of human development over the past one million years, even over the period of the past 100,000 years, a date of 6000 years ago seems very recent — even by comparison with the development of agricultural economies, which by common consensus can be traced back to at least 10,000 years ago, with roots that go even deeper in time. Quite elaborate arguments have been constructed to explain this late development of interest in marine resources, and usually focus on supposedly high labour costs or technical difficulties as barriers to exploitation until technological development, human population growth, or decline in availability of plants and animals on land forced people to explore new sources of food (eg Osborn 1977).

However, there is a simpler and increasingly popular explanation for these time trends. The date of 6000 years ago coincides quite closely with the period when the postglacial sea-level rise associated with the melting of the continental ice sheets reached its present level. On this argument, the appearance of coastal sites in great numbers throughout the world after about that time is a simple function of visibility and preservation of evidence. Before 6000 years ago sea levels were lower, shorelines further out to sea, and most of the evidence of their use now

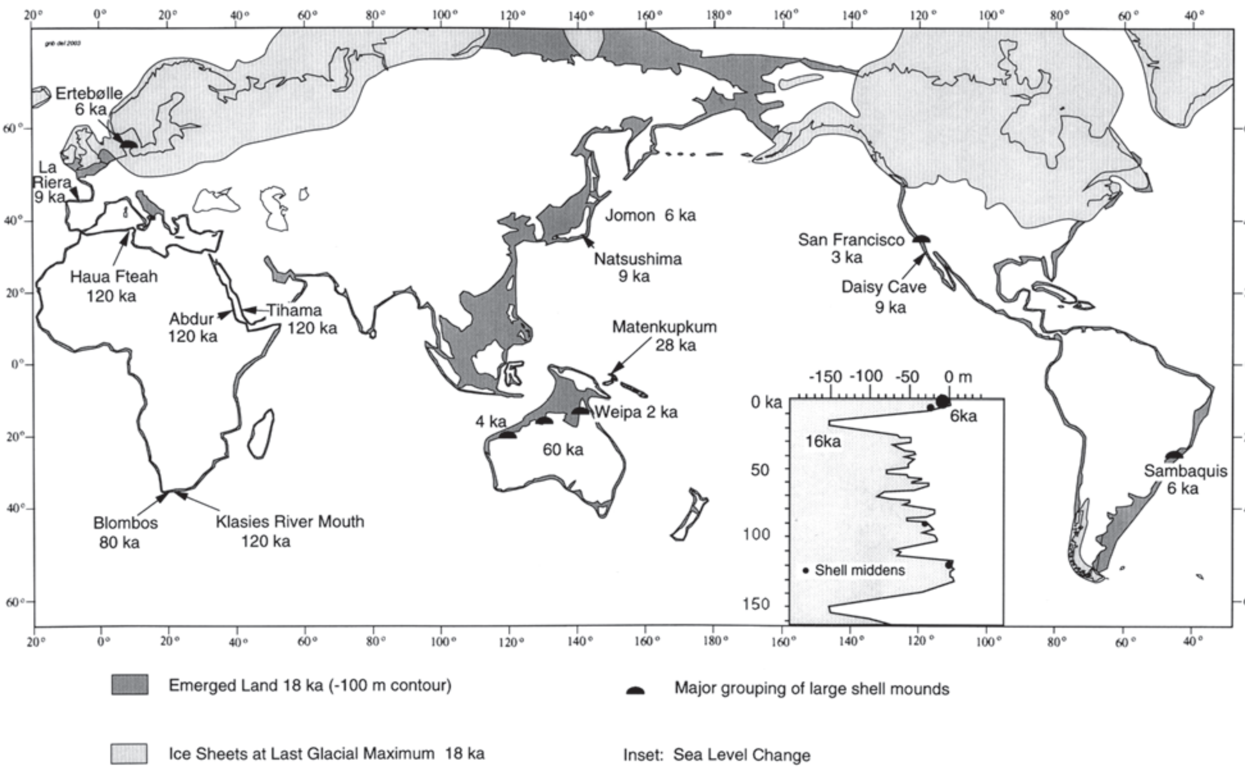


Figure 1.1 Map of the world showing the extent of Continental Shelf exposed at the maximum marine regression, sites mentioned in the text, and the pattern of sea-level change and its relationship to shell midden occurrences over the last glacial-interglacial cycle

submerged or destroyed. The rare sites in the 12,000 to 6000 BP time period are usually to be found either on steeply shelving coastlines or in privileged positions of preservation, in caves for example, where shorelines in the final stages of sea-level rise would have been quite close to the present shoreline, or on coastlines that have since undergone isostatic or tectonic uplift. Progressive increase in marine shells in late glacial and postglacial deposits in long coastal cave sequences is also demonstrably correlated with sea-level rise and progressive narrowing of the distance between seashore and cave location, the presumption being that when the seashore was further away molluscs and other marine foods were processed closer to the contemporaneous shore in what are now underwater locations (Bailey and Craighead 2003). Archaeological deposits with significant numbers of marine shells have also been found in association with the high sea levels of the last interglacial period at various locations in Africa and the Red Sea Basin, which tends to reinforce the correlation between sea-level change and visibility or preservation of evidence.

In spite of this growing body of indirect clues to the possible existence of earlier coastal and marine-oriented societies, there is still very little hard evidence. Sceptics might point out that the underwater sites so far discovered and excavated, for example, in the Baltic (Fischer 1995b) or the eastern Mediterranean (eg Galili *et al* 1988), are of relatively recent date and tell us little that we could not already find out from sites of equivalent date on land. It is one thing to say that evidence could have existed but has been destroyed or buried, and quite another thing to demonstrate that such evidence actually existed. And it is very easy to move from the statement that the evidence could have existed, but cannot be recovered, to the belief that the evidence never existed at all.

Land-based views of world prehistory

Another powerful factor in discounting the importance of coastlines is the prevailing view to be found in textbooks of world prehistory that the general course of human development has been a land-based one, progressing from gathering and scavenging to big-game hunting, and thence to the domestication of plants and animals, and the growth of population fuelled by agricultural surplus. This view has of course gained much of its currency from the absence of early coastal evidence already noted, but also reinforces a negative attitude to coastal settlement as a mode of existence that is believed to have been generally late in date, geographically marginal, or in some way anomalous. From this terrestrial viewpoint, coastlines are seen literally as margins on the edge of continental land masses, rather than as centres of innovation and pathways for movement and communication. Lowered sea levels are interpreted largely in terms of their effects in creating land bridges which allowed big-game hunters to colonise new continents, rather than in terms of their palaeogeographical effects on coastal environments and the visibility of coastal archaeology (cf Gamble 1993; Klein 1989). Australia, as the exception to this rule, with its evidence of precocious maritime skills and planned sea journeys dating back at least 50,000 years, is easily dismissed as the continent of hunters and gatherers, bypassed by the main currents of human cultural development (cf Lourandos 1997).

Ethnographic bias

Coastal hunters and gatherers have also been poorly served by the descriptions of early European travellers and ethnographers. Charles Darwin's (1839, 235–6) descriptions of the Indians of Tierra del Fuego are not untypical though they have been particularly influential:

> These are the most abject and miserable creatures I anywhere beheld . . . Viewing such men, one can hardly make oneself believe that they are fellow-creatures, and inhabitants of the same world . . . The habitable land is reduced to the stones which form the beach; in search of food they are compelled to wander from spot to spot, and so steep is the coast, that they can only move about in their wretched canoes . . . How little can the higher powers of the mind be brought into play! What is there for imagination to picture, for reason to compare, for judgement to decide upon? To knock a limpet from the rocks does not require even cunning, that lowest power of the mind.

This language of 'wretchedness' can also be found in the early descriptions of the Bushmen of the Cape coast of South Africa by the early Dutch explorers such as Van Riebeek (Tooke 1908) or of the Aborigines of Australia (Dampier 1697).

As sea-borne travellers these early European explorers had no intermediate gradations of culture, such as an overland traveller might have experienced, to prepare them for what they would find on first landfall. The discovery of 'primitive' indigenes in distant lands after weeks or months at sea must have seemed as shocking as the discovery of new life forms on a distant planet by a galactic explorer. Coastal hunters and gatherers were, by definition, the first people to be encountered, and have thus been especially exposed to Eurocentric misconceptions.

These ideas soon entered European prehistory. Sir John Lubbock explicitly used the Indians of Tierra del Fuego as an analogy for the inhabitants of the Ertebølle shell mounds, recommending Darwin's description as 'a very good account' of the way of life to be associated with a diet dominated by shell-fish (Lubbock 1865, 189). Gordon Childe's comments in the first edition of the *Dawn of European Civilization* carry a clear echo of Darwin's youthful comments nearly 100 years later. Referring to the Mesolithic shell middens in the coastal caves of Asturias in northern Spain, Childe described them in the following terms: 'The Asturian was the creation of a miserable population of food-gatherers who dwelt in caves on the shore and lived largely on shell-fish ... No originality has ever been claimed for this poverty-stricken remnant of the Magdalenian'. (Childe 1925, 17).

This type of derogatory description gained added impetus in the European context by the wish to highlight the contrast between a supposedly degenerate Mesolithic and a dynamic Neolithic bearing the new elements of agriculture and civilization from the Near East that were believed to be the foundation of our modern world, thereby creating a fault line between Mesolithic and Neolithic studies that persists to this day (Zvelebil 1996).

Even Grahame Clark, early student and champion of the Mesolithic, could find little better to say than that 'a diet in which shell-fish are a mainstay is normally associated with a low level of culture, a proposition which is hardly contradicted by the attainments of the Capsians of the Tagus Valley, the Tardenoisians of the islands off Morbihan, the Obanians of western Scotland or the Ertebølle people of the Litorina coasts of Denmark' (Clark 1952, 63).

Not until the latter part of the 20th century did the very different descriptions of the Indians of the north-west coast of North America begin to influence interpretations of Mesolithic coastal archaeology as examples of 'complex' hunters and gatherers with many of the economic and social attributes once believed to be exclusively associated with agricultural societies (Renouf 1984; Rowley-Conwy 1983). Moreover, it is a notable fact that some of our best ethnographic descriptions of coastal hunters and gatherers, and indeed some of the most abundant archaeology, are in the southern hemisphere or at high latitude in the northern hemisphere, regions that are generally viewed as marginal to the main highways of human development. And this is no coincidence, for marine ecological productivity, unlike productivity on land, tends to increase with increasing latitude, and many of the most productive coastal waters in the world are to be found at higher latitudes in both northern and southern hemispheres. Moreover the marginality of these higher latitude regions for agriculture means that hunters and gatherers have survived long enough to enter the modern era as targets of European observation.

Thus both historical and geographical factors have conspired to reinforce the notion of primitiveness or marginality associated with coastal hunters and gatherers.

Promotion by non-archaeologists

Finally we should give due acknowledgement to the impact both positive and negative of those who have promoted the significance of coastlines in human evolution, a group notable for the absence of archaeologists until the end of the 20th century. First among these must surely be Lewis Henry Morgan who in his great work on *Ancient Society or Researches on the Lines of Human Progress from Savagery through Barbarism to Civilization* expressed what must count as one of the most prophetic insights into the significance of marine and aquatic resources, and one that it has taken archaeologists more than 100 years to follow up:

> Fish were universal in distribution, unlimited in supply, and the only kind of food at all times attainable ... Upon this species of food mankind became independent of climate and of locality; and by following the shores of the seas and lakes, and the courses of rivers could, while in the savage state, spread themselves over the greater portion of the earth's surface. ... In reliance upon fruits and spontaneous subsistence a removal from the original habitat would have been impossible (Morgan 1878, 21).

This theme was later taken up by the American geographer Carl Sauer in his 1962 paper 'Seashore-primitive home of man?', though his immediate inspiration was Sir Alister Hardy's provocative 1960 paper 'Was man more aquatic in the past?'. Later treatments include Elaine Morgan's 1982 gender version of Hardy's hypothesis, *The Aquatic Ape*, Stephen Oppenheimer's 1998 *Eden in the East: the drowned continents of Southeast Asia*, Richard Rudgley's 1998 *Lost Civilisations of the Stone Age*, and Grahame Hancock's 2002 *Underworld: the mysterious origins of civilisations*.

None of these authors can claim primary competence in archaeology, and some of these treatises are frankly journalistic in style, something which, in its turn, has no doubt reinforced the sceptical attitude of archaeologists and palaeoanthropologists. They are a testament both to the powerful fascination for 'lost civilisations' and the intellectual vacuum created by lack of interest on the part of professional archaeologists. Even Sandra Bowdler's (1977) coastal colonisation hypothesis for Australia has generally received short shrift at the hands of the critics, all the more surprising in a continent which must have been colonised in the first instance by sea-borne journeys and which has some unusually early, 33,000-year-old, evidence for fishing and shell-gathering at the cave of Matenkupkum (Gosden and Robertson 1991).

Why are early prehistoric coastlines important?

Increasingly I believe that the conventional picture of world prehistory should be turned on its head and that we should regard the use of shorelines as the primary human adaptation, one that has played a significant role in all the large-scale transformations of human development. This is not a plea for a return to the 'aquatic ape' hypothesis, which focused primarily on anatomical and physiological adaptations to a semi-marine existence, a hypothesis that remains controversial. Nor is it to advocate that we should ignore plants and animals on land or that we should imagine periods of human existence when humans or proto-humans lived on nothing but marine foods. It is, rather, to highlight a simple point about the attractions of shorelines, one that applies with particular force to sea coasts, but which can also be generalised to lakeside settings and the littorals of major rivers. These sorts of environments are manifestly attractive for human settlement and probably have always been so, because they offer the following advantages:

1 Diversity of food supplies within close proximity, including marine resources which in favourable conditions can occur in great abundance
2 More equable climatic conditions
3 High water tables and good water supplies
4 Fertile conditions for plant and animal life on land
5 Availability of aquatic resources including 'gathered' and 'hunted' resources, many of which would have been accessible with little or no special equipment, including intertidal molluscs, fish caught by hand or trapped in natural fish traps, and the scavenged carcasses of sea mammals and seabirds
6 Other easily collected bounties exposed along the shoreline such as cobbles for making stone tools or other raw materials
7 A variety of niches offering opportunities for circumventing competition with other 'hunters' and 'gatherers', ie specialised carnivores or plant-eaters, or for avoiding predation
8 Easy pathways of communication and population movement, especially with the aid of simple water craft

It is clear that some of these advantages, such as improved local climate and water supplies, apply to the terrestrial environment in a coastal or littoral setting as well as the aquatic environment, and could have had an important impact on the landward aspect of early human economies as well as the maritime aspect. That, of course, is an added reason for taking seriously the study of now-submerged coastal regions, which may have represented some of the most attractive territory for terrestrial hunting and gathering in a Palaeolithic context. Here I want to emphasise the potentials for marine and aquatic exploitation. Perhaps the most comprehensive case in support of this viewpoint is Erlandson (2001; see also Bailey and Milner 2002), who has summarised the evidence for the role of aquatic resources at all periods of human evolution including the earliest period of human emergence in the African Rift. Here I shall concentrate on just two issues.

Human dispersal and migration

The influence of coastlines and marine subsistence in facilitating the dispersal of early human populations 'out of Africa' from an ancestral source of origin in the African Rift has already been alluded to in reference to the comments of Lewis Henry Morgan. In recent years new discoveries and the reinterpretation of older ones have brought to light extensive, if scattered, evidence for the use of shell-fish and other marine resources in a number of deposits dated to the high sea levels associated with the last interglacial period at about 125,000 years ago or the earliest stages of the last glacial period a little later. Notable here are the deep deposits found in long cave sequences such as the Haua Fteah in Libya (McBurney 1967), and Klasies River Mouth (Deacon and Shuurman 1992) and Blombos Cave (Henshilwood *et al* 2001) in South Africa. To these should be added the recently discovered open air site of Abdur in Eritrea (Walters *et al* 2000), where hand axes are reputedly associated with oyster shells and animal bones on a raised coral terrace of the Red Sea clearly dated to 125,000 years ago (Fig 1.1). This coincidence of dates has led to the idea that the consumption of marine resources was an innovation of anatomically modern humans (AMH), which facilitated their dispersal out of Africa.

This is an attractive idea, but its main difficulty, leaving aside arguments about 'out of Africa' versus 'multi-regional' models of AMH origins, is the assumption that the earliest visible evidence of shellgathering is the earliest actual evidence. There seems no more reason to accept this assumption than the once popular assumption that the first appearance of shell mounds in the mid-postglacial represents their earliest possible existence. Many Lower Palaeolithic sites are found in coastal locations, often eroding out of raised coastal beaches or raised river terraces in Africa and Europe, as Sauer (1962) long ago pointed out. Actual survival of biogenic remains is rare, Terra Amata (de Lumley 1969) being an exception where a small number of marine shells has been claimed in association with Lower Palaeolithic artefacts. The vagaries of preservation of organic materials in what are mostly open-air sites, and the variable proximity to the nearest adjacent contemporaneous shoreline, are two factors that leave open the question of what marine component was associated with the settlement of these much earlier sites. Certainly higher and earlier terraces formed by progressive opening of the Red Sea Rift and associated with Palaeolithic artefacts are present along the Arabian coastline (Zarins *et al* 1981), offering an opportunity to test the interpretation of the Abdur evidence in earlier contexts.

One thing is certain, however, and that is that any human or hominid dispersal out of Africa would have required intimate contact with coastlines, and the crossing of water barriers to a greater or lesser extent, with the possible exception of a narrow corridor across the Sinai Peninsula. Even the Sinai route, however, hugs the Mediterranean coastline and would also have required negotiation of the Nile Delta. The possibility of very early sea crossings and contact across the narrowest parts of the Mediterranean and the Bab el Mandeb Straits at the southern end of the Red Sea is now under active investigation (see Flemming *et al* 2003; Stringer *et al* 2000; Stringer 2000).

Similar considerations are now being applied to the Pleistocene colonisation of the Americas, where the traditional concept of a migration across the Bering land bridge and through the so-called ice-free corridor of the North American ice sheet is increasingly being called into question in favour of a coastal route (Erlandson 2000). The case for the nature and antiquity of sea crossings in South-East Asia and across the Wallace Line to Australasia remains an active and controversial issue (see Bednarick 2003 and comments). The expansion of human settlement into the British Isles, whether we are dealing with the earliest evidence in the Middle Pleistocene, or the reoccupation of newly exposed land after the last glacial period might well benefit from a similar perspective.

Emergence of 'complex' societies

The notion of complex hunters and gatherers that emerged twenty years ago has been closely associated with maritime societies and in the European context with Mesolithic shell mounds such as the Danish Ertebølle. Complexity here refers to features such as sedentary settlement, increased population size, food storage, and development of social hierarchies. The classic ethnographic example is the Indians of the north-west coast of North America (Rowley-Conwy 1983). The correlation of such characteristics with coastal environments is no surprise, given their advantages outlined above, especially on coastlines with shallow embayments and river estuaries providing conditions of high ecological productivity and abundant supplies of marine foods.

On shallow shorelines and river estuaries with extensive mud flats providing suitable habitat for vast quantities of bivalve molluscs, the large quantities of discarded shell accumulated over many centuries have resulted in massive mound deposits. Oyster mounds such as those of the Ertebølle are often several hundred metres long and up to 5m thick, and a single such mound can contain literally billions of mollusc shells. These sizes and quantities are typical, and such sites are widely distributed throughout the world with particular concentrations in large bays and river estuaries, including such famous examples as the mounds of San Francisco Bay, the Jomon mounds of Japan, the Brazilian sambaquis, and the Weipa shell mounds of northern Australia (Fig 1.2 and Fig 1.3).

In some cases, it seems that the shells have accumulated as the simple byproduct of domestic consumption and settlement repeated in the same place over many generations, literally under the feet of the inhabitants, rather like a Near Eastern tell. In other cases, the sites seem to have been used primarily as shell dumps for the processing of the molluscs and the removal of their meat for

Figure 1.2 Aerial view of shell mounds on the east bank of the Hey River near Weipa on the Cape York Peninsula of northern Queensland, taken in March 1993 at the end of the wet season. There is one cluster of shell mounds in the middle of the picture, an isolated mound to the left and another one to the right. The mounds are partly obscured by large trees growing on them. The sites are located on flat and marshy open ground. The open ground immediately in front of this is flooded by high tidal water and separated from the main river channel by a thick belt of mangrove vegetation. (Photo by author)

Figure 1.3 Close up of shell mound on the east bank of the Hey River, taken during the dry season of 1972. (Photo by author)

consumption at settlements elsewhere. In the low latitude subtropical regions of the world, the shell middens often form steep-sided dome-shaped or conical mounds that can reach spectacular dimensions, like those of northern Australia, or the sambaquis of Brazil, the tallest of which are 20m high (Gaspar 1998). Although the concentration of shells in this manner may be related in part to the self-selecting effect of using a dry camping spot in a seasonally waterlogged environment, it seems certain that these mounds must have formed impressive features of the landscape that could easily have acquired ritual or symbolic connotations. Luby and Gruber (1999) have noted the many human burials found in the California mounds and have suggested that feasting on shell-fish might have been an important part of the burial rite, and the heaping up of the discarded shells a deliberate act designed to emphasise the site as a marker of the ancestral burial site, analogous to the artificially constructed earth and stone mounds built over burial chambers by many agricultural societies. Many shell mounds in other parts of the world also contain human burials alongside evidence of domestic activities. At least one of the Brazilian mounds, Jabuticabeira II, seems to have been used solely for burial of the dead and associated ritual, since it has failed to produce any indicators of daily settlement and subsistence activity despite extensive excavation (Gaspar 1998).

Such features are of course closely consonant with the notion of a complex hunter-gatherer society. The fact that the shell mounds that are so often the archaeological marker of complexity make a relatively late appearance fits nicely with a conventional ladder of progress in which complex forms of social organisation appear relatively late in the sequence alongside other social and economic developments such as early agriculture and urbanism. The corollary of such a view, of course, is that we should not expect to find shell mounds like these at significantly earlier periods of the Pleistocene. But if the coastlines on which such sites might be found are now submerged, such a notion cannot be tested without underwater exploration. And if coastal shell mounds were to be found on substantially earlier coastlines, that would have a dramatic impact on our conventional understanding of the general course of world prehistory.

What is the likelihood that coastal sites of this type might have existed during periods of lower sea level and survived subsequent inundation? A first task is to identify periods and areas where the appropriate environmental conditions once existed. This may not be as easy as we imagine. Estuarine mudflats are quite short-lived in geological terms, and may require time lags of up to several thousand years between stabilisation of sea level after a period of rapid change and the build up of sufficient sediments to create suitable molluscan habitats. Rocky shorelines are less sensitive to habitat change resulting from rapid sea-level change, but they also generally support fewer molluscs. If shell mounds of substantial size were accumulated at an earlier period of stable sea level, they might not be easy to distinguish from natural shell banks in acoustical surveys. However, shell deposits with the steep-sided and domed or sub-conical shape of the shell mounds at Weipa or the sambaquis of Brazil have a very distinctive morphology, and if they survived inundation, might have a better chance of being detected.

Conclusion

As far as the wider archaeological community is concerned, it will not be enough to demonstrate that ancient land surfaces and *in situ* archaeological materials of prehistoric date can be preserved underwater after inundation by rising sea level, or that they can be located, excavated, and analysed in the same way as terrestrial materials. What the sceptical archaeologist will want to know is what difference, if any, such discoveries can make to our understanding of prehistory. What new information can underwater prehistoric archaeology bring to light that cannot be obtained more easily and much more cheaply on land?

I think there are two clear answers to this question. The first is that unless we go underwater whole areas of understanding about world prehistory will go by default, especially the early history of shorelines and marine resources, and the benefits that they could have brought in facilitating the expansion and growth of human populations, and stimulating social and cultural change. The convention that coastlines were of little significance until very late in the human story is just that, a convention. The main burden of this paper has been to demonstrate just why this convention should now be subjected to the most critical scrutiny. The belief that there is no need to investigate earlier coastlines because there is no evidence there is tantamount to saying that there is no need to go out and look for new evidence because we already know in advance what the answers are!

The second answer to the sceptic's question has to do with the relative difficulties, costs, and benefits of underwater work as compared with similar investigation on land. The easy assumption is that underwater work is necessarily far more costly and more uncertain than on land. Apart from the added problem of seeing through the water column or moving underwater, the presumption is that the original land surface has been exposed underwater to much greater forces of erosion, disturbance, displacement, or burial under subsequent sediment than would have been the case on dry land, and indeed in some areas to the additional damage of human impact resulting from such activities as the 'ploughing' of the sea bed by trawling nets. On top of that are the large costs of boat hire and diving gear, and the teams of specialists with different expertise that need to be assembled. But how different is this really from terrestrial archaeology? Large-scale operations have long become the norm in archaeology above modern sea level, involving operations spanning many years and even decades, large teams of specialists, the use of specialist and often expensive equipment, and various forms of remote sensing to improve visibility, including aerial photography, satellite imagery, and drilling beneath alluvial and colluvial sediments. Moreover, much of the earth's surface has been heavily disturbed by subsequent processes such as agricultural development, ploughing, and the more general impact of modern development, to say nothing of erosion and sedimentation whether induced by natural processes or human activity. As on land, underwater erosion is often a two-edged process, making material available for discovery, but also exposing it to subsequent displacement, degradation, and destruction. To the problems of sub-aerial weathering and bacterial and chemical decomposition on land, we also have to add the destructive effects of generations of pilfering, looting, and excavation. This is not to say that working underwater might actually turn out to be easier and more productive than on land, but rather to emphasise that the balance of advantage and disadvantage is by no means obviously weighted in any one direction. Discovery of archaeological sites underwater remains a more haphazard process than on land, for example, while conditions of preservation underwater can be spectacularly better.

In short, there are no good excuses for not promoting and pursuing the investigation of prehistory underwater. One of the great axioms of archaeological field survey on land, which also applies in a more abstract way to much intellectual endeavour, is that often we do not find anything until we know what we are looking for, and we do not know what we are looking for or even where to start looking until we find something. This is a paradox — probably a universal one — which can only be resolved by many trials and errors in which we develop simultaneously both the techniques of observation that enable us to make finds, and the theoretical frameworks that give us expectations and predictions about what to look for and where to look for it. As on land so underwater, progress will depend on elaborating problems in need of investigation that make the search worth pursuing, targeting likely areas for discovery of relevant material, and developing strategies of survey and recovery. Often those different elements of research will be pursued separately, but the more they can be brought into interaction, the faster will be the rate of progress.

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2 The prehistory of the North Sea floor in the context of Continental Shelf archaeology from the Mediterranean to Nova Zemlya *by N C Flemming*

Abstract

The area of the UK Continental Shelf out to a sea depth of 200m is greater than the area of the present UK dry land. The area of the whole north-west European shelf, including the whole North Sea and Baltic, Irish Sea, Celtic Sea, Channel, and Biscay shelf, is three times as much. The southern shelf area, south of 53° north, has never been glaciated, and was vegetated and grazed by periglacial fauna, and probably occupied by hominids, at every low sea period during the last half million years. The climate, vegetation, precipitation, hydrology, and fauna of this submerged land area have had a significant role in determining the course of prehistory in north-west Europe, and it is now possible to retrieve the *in situ* archaeological evidence. The north-west European shelf is a difficult area in which to work, and the oceanographic conditions are severe, but evidence from submerged archaeological sites in the Mediterranean, northern France, the Baltic, and the UK shallow waters shows that archaeological deposits can and do survive with stratigraphic integrity at depths of up to 25m below present sea level, while scattered finds show that the shelf was occupied when the sea level was at least 40m below present in the Mediterranean, and 140m below present in the northern North Sea. Palaeolithic sites from offshore islands in Russia show that the analysis can be continued throughout Scandinavia and the Arctic shelf. There are numerous geomorphological contexts within which archaeological deposits survive marine transgression. The time is now ripe for an appraisal of the intellectual questions which can be resolved with the accumulated data, and for new policies towards the gathering of more data.

Introduction

The North Sea is everywhere shallower than 150m, but the environment is harsh and difficult for the conduct of submarine prehistoric research. The extreme physical oceanographic conditions, high tidal amplitude, strong tidal currents, and wave action both from the Atlantic and generated by local storms, mean that archaeological deposits may have been disturbed by the force of water movements, modern sediments such as sand waves may be moving over archaeological sites, and working conditions are difficult for divers. Statistically some artefacts will survive on the seabed, some will be exposed for us to find today, and some primary sites will remain uneroded in this stratigraphic context. Finds to date already confirm this broad picture. The geological and sedimentary conditions on the floor of the North Sea can be identified from the publications of the British Geological Survey UK Offshore Regional Reports (eg Cameron *et al* 1992), and the BGS Map Series, 1:250,000 scale 'Seabed Sediments'.

Single archaeological artefacts were trawled up out of context in the North Sea 70 years ago (Louwe Kooijmans 1970–71; Coles 1998) and modern research has shown the essential role of the North Sea floor as an occupied territory during the last glaciation (Coles 1999). Marine archaeologists have found submerged sites close by in the English Channel (Scuvée and Veragué 1988; Momber, this volume) and the Baltic (Pedersen *et al* 1997; Fischer, this volume; and Grøn, this volume). But the discovery of settlement sites and stratified material in context in the body of the North Sea itself has so far defied any logical approach. It has not been attempted systematically. (One submerged site on the coast at Brown Bay, Northumberland, has been found during 2003, after the workshop reported in this volume; Penny Spikins, personal communication, see University of Newcastle website http://historical-studies.ncl.ac.uk/SALT/)

Evidence from known submerged prehistoric sites in other seas shows that materials are preserved in context most effectively where the taphonomic conditions ensure a local low energy environment and moderate sediment transport, or permanent sediment cover. These conditions can occur for many different reasons (Flemming 1983a, 1998; Grøn, this volume; Maarleveld, this volume). Discovery and study of sites depend upon ease of access for small research vessels and lightly equipped diving teams of trained archaeologists or volunteer divers. The North Sea fails to meet many of these criteria. It is stormy with strong local wind systems; large swell waves propagate into the northern North Sea from the Atlantic; long wavelength waves pile up and break over the shoals and banks; there are strong tidal streams; there is a very active sand transport pattern with extensive dynamically maintained banks and ridges of modern marine sands (Kenyon *et al* 1981); there are fields of active sand waves which move slowly like sand dunes in the desert; there are large rivers bringing down great quantities of modern sediments; the concentration of suspended sediments and seasonal phytoplankton production mean that the visibility for underwater work is poor.

The topography of the coastline and offshore banks and shallows tends to make work at likely sites offshore both expensive and time-consuming, requiring heavy equipment or boat journeys of 10–100km or more. The ideal location for the discovery of workable sites is within an archipelago, or in the lee of islands, and this is demonstrated by the discovery of submerged Mesolithic sites in the Baltic (Skaarup 1983; Andersen 1980; Fischer 1991, 1995b; Lübke 2001, 2002) and more recently in the Solent (Momber 2000b, 2001). Low energy environments do exist in the Friesian Islands, Wadden See, in the estuaries and bays of East Anglia, and the Wash and the Humber, but these environments are also associated with tens of metres' thickness of Holocene sedimentation.

As we go offshore from the relatively straight shorelines of the North Sea we find that there are many submerged environments which had the characteristics of low energy during marine transgression several thousand years ago, and therefore now probably contain preserved archaeological sites (Flemming 2002). However, to work on these sites we need first to find them, and then to conduct acoustic and diving research often 50–100km offshore. This is a very different environment from the typical coastal site where sports divers are as likely to find artefacts as the professional archaeologists.

It is therefore not surprising that, 30 years after the start of serious research into submerged prehistoric sites in the Mediterranean and Baltic, the North Sea has not been tackled in a concerted manner. Other papers in this volume (Verhart; Glimmerveen *et al*; Maarleveld and Peeters; van Kolfschoten) describe the admirable work on the Dutch coast aiming to understand and interpret the palaeontological and archaeological materials retrieved by fisheries trawling and sand dredging, but these authors stress the absence, so far, of archaeological materials in stratigraphic context.

With the advent of new government and European legislation and directives (Oxley, this volume; Maarleveld and Peeters, this volume) it is now incumbent upon the offshore and coastal industries (oil and gas, aggregate dredging, harbour works, fisheries, offshore windfarms) to collaborate with conservation agencies and academic bodies in order to protect, preserve, and understand submarine prehistory, and to mitigate the impact of industrial activities on the prehistoric sites. By working with industry, the research community and the conservation agencies now have the possibility to discover and analyse prehistoric sites in coastal waters and in the centre of the North Sea.

This paper considers the lessons which can be learnt from submarine prehistoric sites in a wider context, and what may be learnt from them in the North Sea and English Channel. I hope also to demonstrate that targeting coastal and offshore submerged prehistoric sites can and will produce archaeological data and insights which are both important and unachievable by other means. In the next section I will consider the oceanographic conditions in the North Sea more thoroughly, and then the Mediterranean, the bordering seas to the North Sea, that is, the English Channel and Baltic, and finally the Arctic.

Oceanographic conditions in the North Sea

Since the discovery of offshore oil and gas on the European shelf in the 1960s, and in response to notorious episodes of coastal flooding in 1953, effort has been devoted to understanding the physics of waves and currents driven by winds, tides, and changing barometric pressure. From the basic physics it has been possible to generate computer models which can calculate the direction and speed of the current at grid intervals of 1–2km across the Continental Shelf, at vertical depth intervals of a few metres, and at time-steps of a few hours, for any given combination of tidal forcing, and meteorological conditions (Fig 2.1). Wind-wave models have the same kind of accuracy (Fig 2.2). The North Sea, including its water and its seabed, is probably the most intensively studied body of salt water on earth (Fig 2.3).

This branch of oceanography has progressed rapidly in the last 10–15 years, but the outputs from computer models are massive gridded data sets which cannot be reproduced in their entirety in text books. Specimen maps are often included in scientific papers (eg Holt *et al* 2001; Proctor and James 1996; Holt and Proctor 2003; Holt 2003; Holt *et al* 2003), while data services are provided to industry and researchers through specialist data banks and computing centres (eg UK Met Office, British Oceanographic Data Centre, Inter Agency Committee for Marine Science and Technology). Most of the information is in documents aimed at the environmental management of commercial operations, or in recent articles in journals and conference proceedings (see for example Dahlin *et al* 2004, Proceedings of the Third EuroGOOS Conference, European Operational Oceanography). Archaeological project leaders planning to work on the UK Continental Shelf are recommended to obtain up-to-date oceanographic data direct from operational oceanographic centres.

Relevant oceanographic variables include surface winds, surface currents, wind-driven waves, swell waves, sea ice, current profiles, stratification of the water column, bottom currents, storm surges, wave action on the seabed, sediment

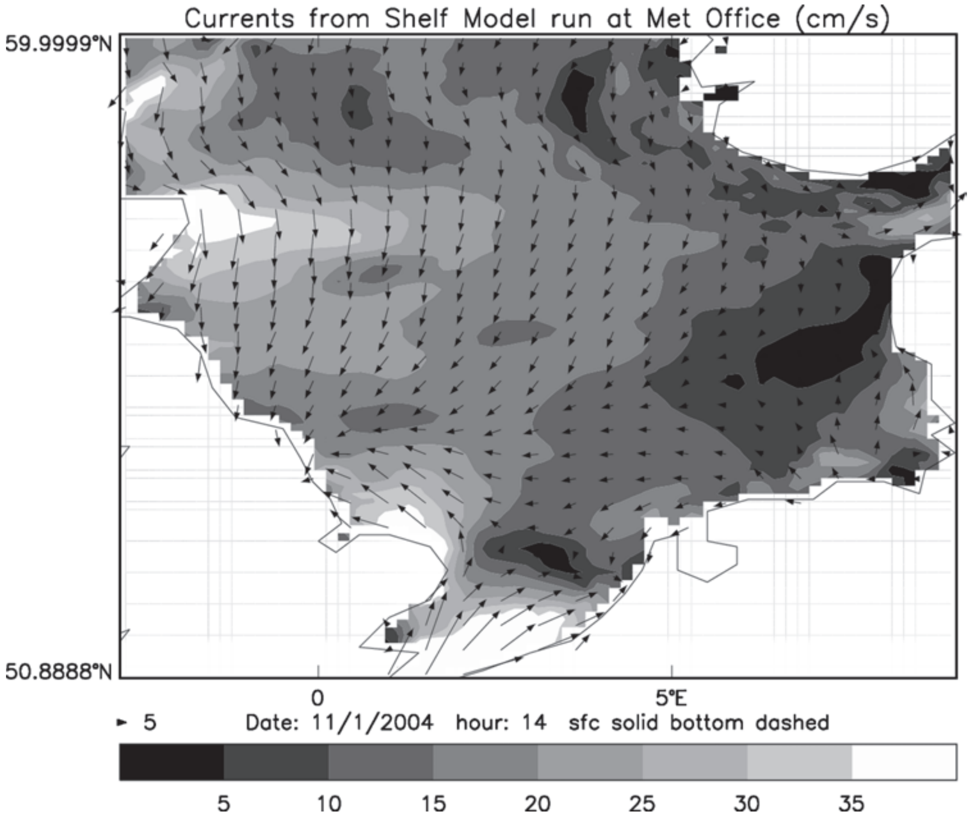


Figure 2.1 Instantaneous tidal current velocities computed on a 12km grid, and plotted here at every third grid point. The shading shows white for the fastest current, and black for the slowest, with velocities in cm per second. (Plot provided by Martin Holt, UK Met Office)

transport on the seabed, suspended sediment transport, river inputs, and geomorphological bedforms such as sand waves, sand ribbons, and sand ripples. Each of these phenomena varied in the past with changing sea level, changing location of the shoreline, supply of clastic sediments, and changing climate. Each individual process such as bottom current or the wind-wave field varies from hour to hour, season to season, and spatially with depth and on a horizontal length scale of the order of 1km, so that the complete description requires a large digital data set, with statistical probabilities that a given value will occur at any given time and place.

The subject of the variability of oceanographic forces in different conditions and geographical configurations is fairly well understood, but is too complex even to summarise here. I can only suggest the importance of further reading, and the inclusion of a qualified expert on any archaeological team working underwater, or on the coast. Some points to bear in mind are as follows:

- Peak conditions, extreme storms, storm surges, highest tides, highest waves, strongest currents, will occur very rarely, but may be responsible for most damage to a site in terms of erosion, and will define the limit of permanent coastal occupation in previous millennia
- Average conditions may be misleading. Cumulative net transports of sediments will tend to be determined by peak forces (waves and currents) which put sediment into suspension, combined with cumulative residual currents which give information on how far the suspended material will move over days or months, and hence onto or away from the site
- Different sediments move very differently, depending upon grain size, and cohesion. Many seabed processes winnow out fine particles leaving a ‘lag’ deposit of coarser particles, which may contain artefacts. The fines are dumped later where the water movement is calmest
- Conditions in the open sea may be very different from those close to the shore, on headlands, around banks and islands. High resolution models can compute the effects of refraction and diffraction, and shoaling on waves, and current regime around headlands and bays, including simulation of local eddies and gyres
- A critical factor in calculating the exposure of a site to wave attack is the so-called ‘fetch’, that is, the distance over which the wind can blow in a straight line to drive waves onto the site. Small coastal indentations and coastal islands can radically reduce the fetch for sheltered locations

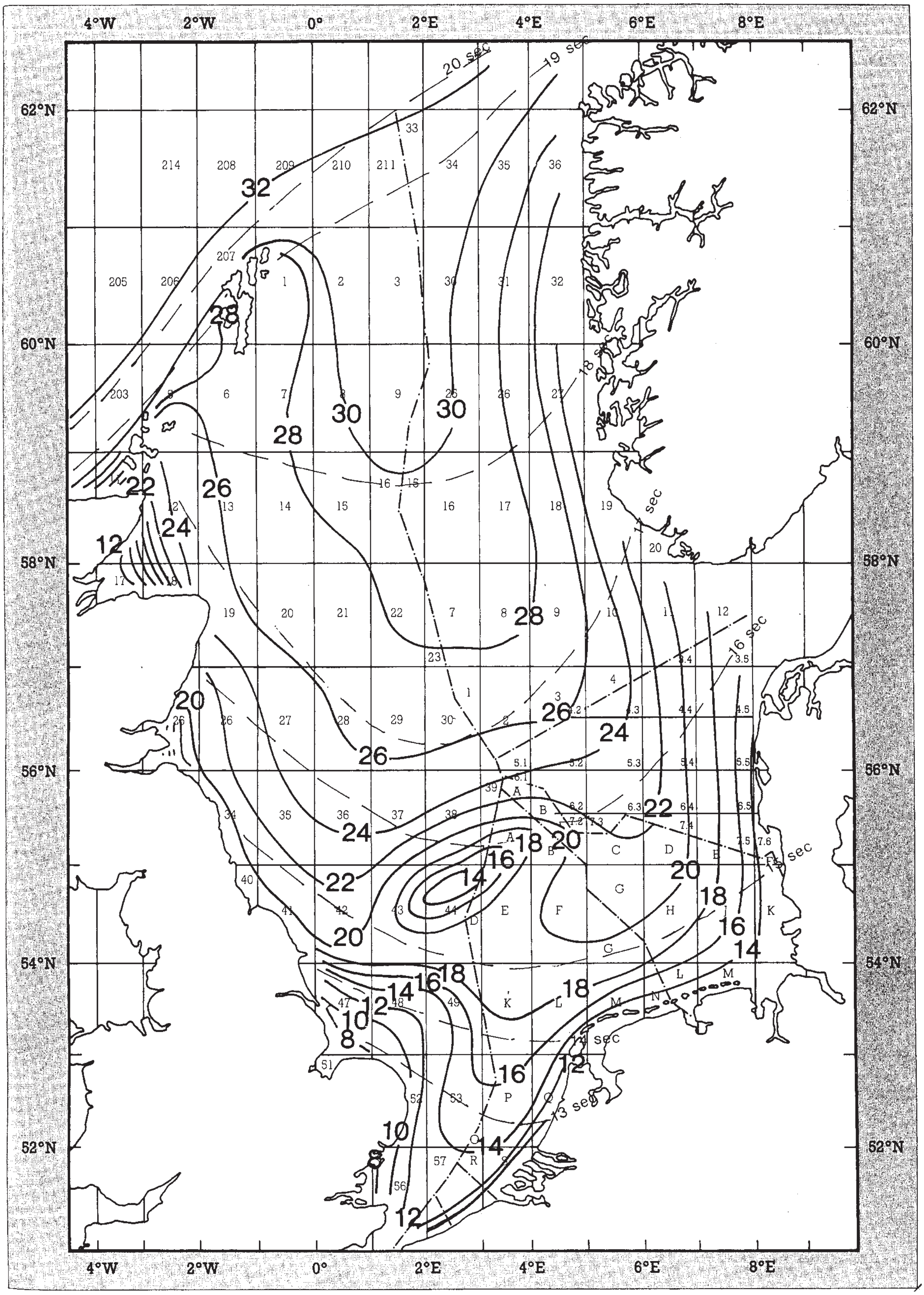


Figure 2.2 The heavy lines contour the extreme 50-year maximum wave height in metres. The long-dashed lines contour the associated crest-to-crest wave period in seconds (from Blackham et al *1985)*

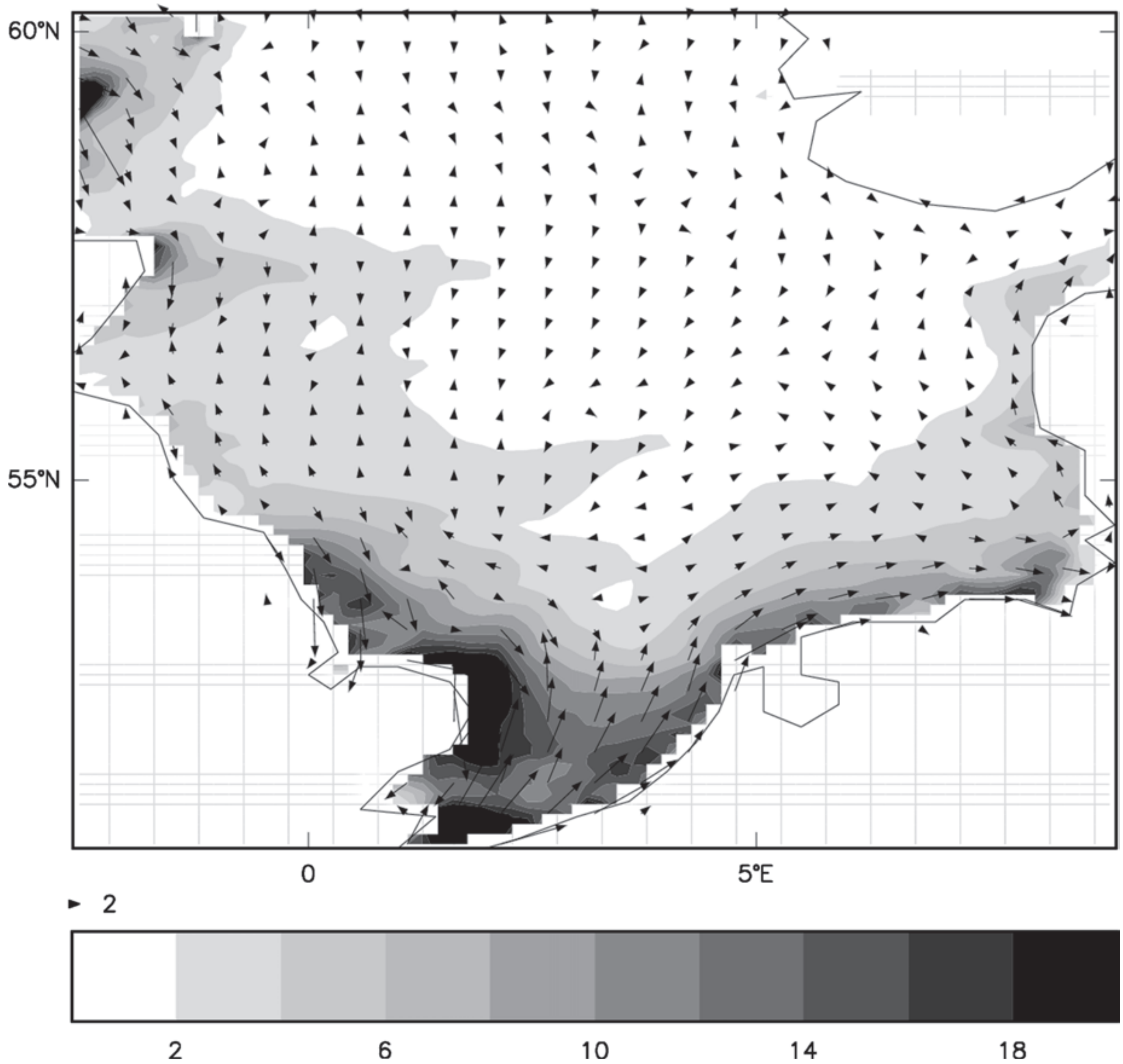


Figure 2.3 Seabed currents in different places are not at a maximum value at the same time. This plot shows the maximum bed stress vector (newtons per square metre) at each point over a 25-hour period on 11 January 2004, due to tidal currents. Data taken from the Met Office run of the POLCOMS 'Atlantic Margin' model on a 12km grid. Note black is highest value on this plot (Acknowledgements: Met Office (www.metoffice.com); Proudman Oceanographic Laboratory (www.pol.ac.uk))

- In calculating the forces on a site on a palaeo-shoreline, or as the sea level rises over it, it is essential to measure the fetch in all directions, and to calculate the highest and longest waves which could strike the site
- Even when the conditions in a sea area suggest that archaeological deposits have probably been destroyed, there will be pockets of protection, depending upon local topographic features at a scale of 20–100m which will be sufficient to provide total preservation of stratified deposits
- Oceanographic, environmental, and ecological factors on a space scale of a few hundred metres will define whether a site is desirable for Mesolithic or Neolithic occupation on the palaeo-coastline (see Fischer, this volume)

In summary, locations potentially favourable for first the occurrence, and then the preservation of submerged prehistoric sites are:

- 'Fossil' estuaries and river valleys
- The flanks of submerged banks and ridges which have been proven to have peat layers, or which are likely to have peat layers
- Valleys, depressions, or basins with wetland or marsh deposits
- Nearshore creeks, mudflats, and peat deposits
- Low gradient beaches with constructive onshore wave action
- 'Fossil' archipelago topographies where sites were sheltered by low-lying islands as the sea level rose

- Niche environments in present coastal zones, wetlands, intertidal mudflats, lochs, and estuaries
- Caves and rock shelters in reentrant bays, fossil erosional shorelines, submerged rocky shores protected by other islands, or in archipelagos
- Deposits of sediments formed within, or washed into rocky gullies and depressions
- Coastal sites comparable by analogy to modern Inuit migratory sites, adjacent to sea ice, giving access to marine mammals as a food resource

A factor which needs to be added to the oceanographic forces in the northern North Sea is the tsunami, or tidal wave, which probably struck the southern coast of Norway and the north-east coast of Scotland in about 7200 BP. This tsunami is attributed to the Storegga Submarine Landslide, in which a large volume of unstable sediments on the continental margin of Norway slumped northwards into a 3000 m deep basin (Long and Holmes 2001, 363). The landslide occurred 300 nautical miles from the mainland coast of Scotland, but the analysis of run-up sediment deposits suggests that waves ran several hundred metres inland on exposed low-lying coasts, and rose 7–8m above mean sea level in constricted bays and lochs (Long *et al* 1989). Although the north-facing coasts of the land in the central North Sea in the time-zone of 7500–7000 BP were 450 nautical miles from the Storegga Slide, the impact might still have been noticeable in coastal settlements. However, dwellings to the south of Dogger, in the region of the Silver Pit, and the sea lake to the south-east of Dogger, would have been completely protected.

The oceanographic conditions in the North Sea are admittedly difficult for submarine prehistoric research, but the continuous recovery of Pleistocene faunal bones (Glimmerveen *et al*, this volume; van Kolfschoten, this volume; Maarleveld, this volume) shows that fossil material does survive, and some of the bones have been worked as artefacts (Louwe Kooijmans 1970–71; Verhart, this volume). In order to put these discoveries into context, I will review briefly the finds which have been made to the south, in the Mediterranean, and to the north, in Russia.

The Mediterranean

Submarine prehistoric research in the Mediterranean area promises to reveal details of human migration and evolution through an understanding of human occupation of the floors of the Aegean and Adriatic Seas during glacial periods, potential crossings at Gibraltar and Sicily, and the evolution of marine transport and fishing technology during the last 20,000 years while agriculture and urban centres were developing in the Middle East. A better understanding of these phenomena carries over into understanding the earlier stages of how hominids and *Homo sapiens* arrived in Europe, and what skills they were using on the Continental Shelf.

The Mediterranean has a narrow shelf in most places, and very low sediment input from rivers. The shelf is wide in the Golfe de Lions, in the Adriatic, between the Aegean islands, and in the Gulf of Sirte. So far, submarine prehistoric sites have only been found on the northern and eastern shores. These include Roussillon in the south of France (Geddes *et al* 1983), the Grotte Cosquer near Marseilles (Clottes and Courtin 1994; Clottes *et al* 1992), submerged caves with Palaeolithic materials in Italy (Riccardi *et al* 1987), artefacts off the coast of Kerkyra in the Adriatic (Flemming 1985), the northern Aegean islands of the Sporadhes (Flemming 1983b), and an extensive range of submerged prehistoric sites on the coast of Israel (Raban 1983; Galili and Nir 1993; Galili *et al* 1993) (see Figs 2.4 and 2.5).

The submerged prehistoric sites on the Mediterranean continental shelves were free of the direct effects of glaciation, and hence preserve, at least in potential, an undisturbed record of coastal climate change, sea-level fluctuations, exploitation of coastal resources, and clues as to the earliest marine crossings from Africa to Eurasia. The possibility of Palaeolithic crossings from Morocco to Gibraltar and from Tunisia to Sicily was analysed by Alimen (1975), and Shackleton *et al* (1984). The collective implications of the known submerged prehistoric sites on the Mediterranean shelf were discussed more fully by Flemming *et al* (2003).

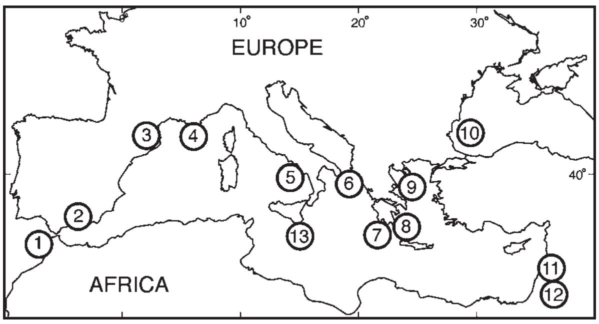


Figure 2.4 Submerged palaeolithic sites, or sites only accessible at lower sea level in the Mediterranean, 1. Cave of Hercules, Tangiers; 2. Gibraltar, Gorham's Cave and submerged caves off Europa Pt; 3. Neolithic site off Leucate; 4. Grotte Cosquer, Palaeolithic; 5. Palinuro, Palaeolithic; 6. Aghios Georghios, Corfu, Palaeolithic; 7. Methoni, Bronze Age; 8. Pavlo Petri, Bronze Age; 9. Aghios Petros, Sporadhes, and Franchthi Cave, Neolithic; 10. Bulgarian coast, Bronze Age sites; 11. Atlit, Israel, Neolithic; 12. Hof Dado, and Tel Harez, Israel, Neolithic; 13. Malta caves (from Flemming et al *2003)*

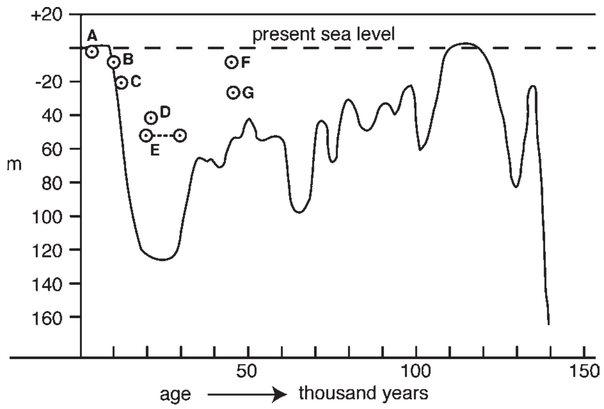


Figure 2.5 Generalised sea level–time curve, with groups of prehistoric sites shown at depth and age on what was dry land. A = Submerged Bronze Age sites due to earth movements, sites 7, 8, and 10 on Figure 2.4; B = Neolithic sites 3, 5, 9, 11, and 12 on Figure 2.4; C = Submerged caves at Gibraltar; D = Grotte Cosquer, site 4 on Figure 2.4; E = Palinuro, 5 on Figure 2.4; F = Aghios Georghios, 6 on Figure 2.4; G = Fermanville, northern France, not shown on Figure 2.4 (from Flemming et al *2003)*

The work by researchers in the Mediterranean has progressed steadily since the first sites were found and excavated in the late 1960s and early 1970s, and can therefore be regarded as a case study which has advanced more than 30 years ahead of research of submerged primary sites in the North Sea. In the gentler oceanographic conditions of the Mediterranean archaeologists have been able to find and study a wide range of well-preserved organic materials, cave wall paintings, burials, and Neolithic settlements with hut foundations in coastal locations.

All the sites found in the Mediterranean so far date to the last glacial cycle, with the earliest submerged materials dating to around 45,000 BP. Nevertheless, the existence of Acheulean tools at coastal sites in many parts of North Africa, Spain, Italy, and the Middle East, suggests that older sites may eventually be found. Evidence of seafaring, marine craft, and early exploitation of shellfish may well come from sites in the Mediterranean or Red Sea for much earlier dates than have yet been found in northern Europe.

Adjacent northern seas and arctic dimensions

In spite of the large quantities of palaeontological materials recovered by trawlers no primary prehistoric archaeological site with deposits in stratigraphic context has yet been found submerged off the coast of the North Sea proper, or further offshore in the North Sea. Submerged primary sites have been found just to the south in the English Channel, and to the north-east in the Baltic Sea. Furthermore, archaeological deposits have been found on the offshore Zhokov Island north of Siberia in the Laptev Sea dating from 8400 years BP (Pitulko 2001; Mithen 2003, 387–92). On the Russian mainland in the Yana River Delta recent archaeological reports by Pitulko *et al* (2004) describe artefacts dating from 27,000 radiocarbon years BP 50km inland from the Laptev Sea. The Russian sites suggest that some people were fully adapted to an arctic or sub-arctic way of life substantially before the last glacial maximum. Such tribes, presumably living with technology and skills similar to those of modern Inuit peoples, would have retreated out of areas which were covered by thick land ice during the last glaciation, but would have been well adapted to remaining close to sea ice, with the proven resources of marine mammals and fish. The conditions in the northern North Sea, around the western shelves of the British Isles, and down to the Bay of Biscay, may thus have provided an ideal environment for such people at the glacial maximum.

The submerged Palaeolithic site described by Scuvée and Verague (1988) is unique in northern Europe since it precedes the last glacial maximum, with a date of about 45,000 BP. Its location off the Cherbourg peninsula near Fermanville at a depth of 20m is intriguing since it would have been overlooking the extension of the River Seine as it crossed the floor of the present Baie de la Seine and flowed westwards to join the great Channel River, which carried all the waters of the rivers of southern Britain, northern France, and Holland, including the Rhine. The report of the site analyses the tool assemblage, geomorphological and oceanographic conditions, sediment accumulation, and the taphonomy of site preservation.

The Isle of Wight is directly opposite the Cherbourg peninsula on the north side of the English Channel. Here, in the shelter of the Isle of Wight, which provides protection from the storms of the open Atlantic to the west, divers have been working for several seasons on a submerged Mesolithic site (Momber, this volume) off Bouldnor Cliff. Tidal current conditions over the site are severe, and the peat deposits containing tree trunks adjacent to the archaeological layers are steadily eroding away. To date this is the only known submerged prehistoric primary site in British waters.

In the sheltered waters of the Baltic there are over 2000 known prehistoric sites (Fischer, this volume). The preservation of the archaeological remains in an undisturbed primary condition depends upon a number of geomorphological and oceanographic factors. The periglacial terrain is dotted with hills and small valleys associated with moraines, so that the rising sea created an immensely complex pattern of islands, bays, and inlets. This was ideal living space for people exploiting marine resources, and using small canoes for transport and hunting. The tidal range is minimal, as are tidal currents, although wind-driven currents can be powerful, and there are complex flows in and out of the Baltic through the channels connecting it to the North Sea. Because of the closely spaced pattern of islands the maximum fetch at many points on the coast is 5–10km, with a maximum of the order of 20km in the more exposed locations. This limited fetch means that wave action is very restricted, and so the disturbance of underwater sites is minimal. Additionally, the small geographical scale of the islands means that there are no large rivers, and the volumes of sediment brought down to the coast are small.

The vertical range of the topography of the Danish archipelago, only a few tens of metres above and below sea level, compares with the low relief of the central North Sea, as pointed out by Firth (this volume). Thus it is possible to envisage the rising sea penetrating rapidly into marshes, inlets, and separating low marshy islands, as the waters spread into the central North Sea. To talk of the Dogger Hills is somewhat generous, when they are only 30m high. The key point to note, however, is the similarity of the terrain between the Danish archipelago and the banks and valleys around Dogger in the time bracket of 9000–7000 years BP. The presence of a tide may have made conditions more complex, but this would have been greatly attenuated by the extreme length and shallowness of many of the inlets and branching rias.

Consideration of the number and variety of submerged prehistoric primary sites which have been found in the sea areas adjacent to the North Sea suggests that the exposed Continental Shelf on the floor of the North Sea would have been as densely occupied as any coastal region of the Baltic Sea, the English Channel, the Mediterranean, or even the Russian Arctic. The fact that submerged primary sites have not yet been found is the result of the difficult topographic and oceanographic conditions, and not due to any *prima facie* evidence that the North Sea was not occupied.

Relevant questions

Other authors in this volume, notably Bailey and Fischer, review the broad intellectual arguments for including the submarine prehistoric component of archaeology as an essential area of endeavour that warrants the devoted attention of scholars and investment by the relevant institutions.

An important part of the information needed to make decisions revolves around uncertainties concerning the probability of sites existing, or being accessible, and the costs of working on them. Has this approach produced data elsewhere that are intellectually valid? Experience from other sea areas shows that the work is feasible and rewarding.

Granted that other areas, especially the Mediterranean, are easier to work in, can the methods used there be transferred or adapted for use in the North Sea? Discoveries in the English Channel, the Baltic, and during 2003 on the English North Sea coast suggest that the answer is positive.

Is the North Sea an outlier on the edge of Europe, or does the information preserved in the North Sea form part of a larger archaeological resource extending to Scandinavia and the Arctic? The British Isles have been connected by dry land to the mainland of Europe for most of the last half million years, and the submerged land area contains a substantial part of the evidence for the human occupation of north-west Europe.

Do the marine and earth sciences provide enough data to understand the human occupation of the Continental Shelf without the identification of primary archaeological deposits? Since we do not know how people exploited the low-lying coastal zones and marine resources during the Palaeolithic and Mesolithic, we cannot make accurate occupation models without more data on actual sites. Finding archaeological sites may sound rather old-fashioned and antiquarian, but the most sophisticated analysis of past human conditions in terms of culture, psychology, evolution, the domestication of animals, and the development of art and technology necessarily depend upon the availability of field data. My contribution to this endeavour is to assist in the acquisition of the field data.

Conclusions

1 Field evidence from adjacent seas shows that prehistoric sites of the last 45,000 years can survive in stratigraphic context on the Continental Shelf in a wide variety of topographic and taphonomic conditions
2 The arctic data suggest that humans were living in northern Europe in sub-arctic conditions before the last glacial maximum. This way of life may have continued around the continental margin, and adjacent to sea ice, throughout the glacial maximum. People did not necessarily all flee southwards to a much warmer climate
3 The low gradients of the North Sea floor were associated with a complex indented coastline of low-lying islands and marshes during the last marine transgression. This terrain produced similar topographies to the Danish archipelago, which is proven to be the location of over 2000 submerged Mesolithic sites

4 Known sites on the coasts of UK and the Netherlands provide a sound basis for study, and for exploration in progressively deeper waters
5 A combination of oceanographic and sedimentological research, using existing data sources and high resolution acoustic surveys, provides the methodology for identifying highly prospective sites, which then have to be examined by coring and diving
6 Data obtained by offshore industries provide a broad basis for information which could not have been obtained on academic research budgets alone.

Section 2 Submerged prehistoric archaeological surveys

Vibrocover being deployed during offshore geoarchaeological investigations (Wessex Archaeology)

3 Submerged Stone Age — Danish examples and North Sea potential *by Anders Fischer*

Abstract

The global sea level rise during the final Palaeolithic and the early Holocene caused dramatic loss of land. Examples from Denmark demonstrate that much of this vanished world is still available to science. In many cases the submerged settlements and hunting grounds are actually preserved in better condition than if they had been above sea level. The preservation quality on the bottom of the North Sea is probably equally good in many places. Huge parts of this area are within reach by the relatively simple methods and equipment hitherto applied in the exploration of the sea floor in the Danish archipelago. An array of indirect evidence points to the existence of intense habitation along the former coastlines and freshwater systems on the floor of the North Sea. Potentially the rather small and simple late Palaeolithic and early Mesolithic sites known from above water in the countries around the North Sea may represent nothing but brief and specialised visits by people who lived on the coast much of the year and there left evidence of a much wider variety of economic and social activities.

Introduction

The global sea level rose approximately 120m during the final Pleistocene and early Holocene (Fairbanks 1989). During this process, vast stretches of fertile land disappeared under the waves around the world. Fortunately for archaeologists and environmental historians, it is not totally lost. Experience from the relatively well-explored Danish sea floor indicate that large proportions of the submerged habitations and tree stumps of the forests that surrounded them are still available — in many cases in a surprisingly good state of preservation.

For a number of years up to 1999 Danish archaeologists conducted systematic underwater surveys to locate prehistoric sites on the sea floor. This was done in close cooperation with the national association of aggregate industries (eg Skov- og Naturstyrelsen 1987, 1988, 1988, 1989, 1991) and the companies building the tunnels and bridges that now connect the island of Zealand with western Denmark to the one side and Sweden to the other (Pedersen, *et al* 1997; Fischer 1992, 1993b, 1996b, 1997b, 1997d).

The highest degree of professionalism was reached in the later half of the 1990s, when the surveys and test excavations were usually conducted from a specially equipped boat, which served as a home and work base for a field staff of between four and six persons (Fig 3.1). The professional divers used ordinary diving equipment: wet or dry suit, pressure air bottles on the back, and a telephone line to an assistant on board the ship. According to Danish law, work is unrestricted down to 25m with this type of diving gear. To work in deeper water an onboard compression chamber is necessary — which implies a larger ship, and makes things more expensive. If the technical facilities are provided it should, however, be possible to work in large parts of the North Sea more or less in the same way as we have done on the shallow parts of the Danish sea floor.

Among the survey methods applied in connection with contract archaeological projects on the Danish sea floor good results have also been obtained with the aid of larger equipment such as industrial sand-pump dredgers and hydraulic digging machines (Fig 3.2). These approaches are certainly coarse, but they are also quick and effective (eg Dencker and Jensen 2000), and for that reason they are recommended for initial inspection where potential sites are covered by deep layers of later sediments.

The information retrieval included recording of existing information from museums, amateur archaeologists, etc, as well as underwater field surveys and test excavations aimed at general accumulation of relevant knowledge for cultural heritage management. These activities were closely coordinated with contract archaeological fieldwork carried out in connection with extraction activities and construction works on the sea floor. As a result approximately 2300 prehistoric sites were recorded from the Danish sea floor (Fig 3.3). That is probably just a few per cent of what is actually existing within the national sea territory. From initial inspections in the adjacent areas of Sweden and Germany the potential for finding submerged sites there appears equally positive (Larsson 1983; Fischer 1993b, 1997d; Hartz and Lübke 1995; Lübke 2003).

The inventory was compiled on the basis of the Danish legislation on nature protection, which directs the national heritage administration to record and protect cultural and historic sites on the sea floor. According to Danish law the border of the sea territory (owned by the state) is defined by the shoreline at normal daily tide. It shall be noted that the normal tidal variation in the Danish archipelago (ie excluding the North Sea) is on the scale of 0.25m and apparently it was not

Figure 3.1 The underwater archaeology survey boat 'Havternen' in pursuit of submerged Stone Age settlements in the Danish archipelago. (Photo: A Fischer)

much different in the Stone Age. Strong winds can locally result in additional lowering of the water surface on the scale of more than a metre.

Find circumstances

A very large proportion of the prehistoric sites recorded on the Danish sea territory have been found by amateur archaeologists walking the foreshore at low water. Other categories of persons responsible for the reporting of sites are sports divers, archaeologically interested professional divers working for the industry, and crew members on ships engaged in aggregate dredging and trawl fishing (Andersen 1980; Skaarup 1983; Smed 1987b).

During the 1980s and 1990s a considerable and scientifically highly significant number of Stone Age sites were located by systematic archaeological field surveys. Much of this work was aided

Figure 3.2 Testing for traces of Stone Age settlement with a hydraulic digging machine on board a float. With such effective equipment only the length of the arm of the machine sets the limit of your access. (Photo: A Fischer)

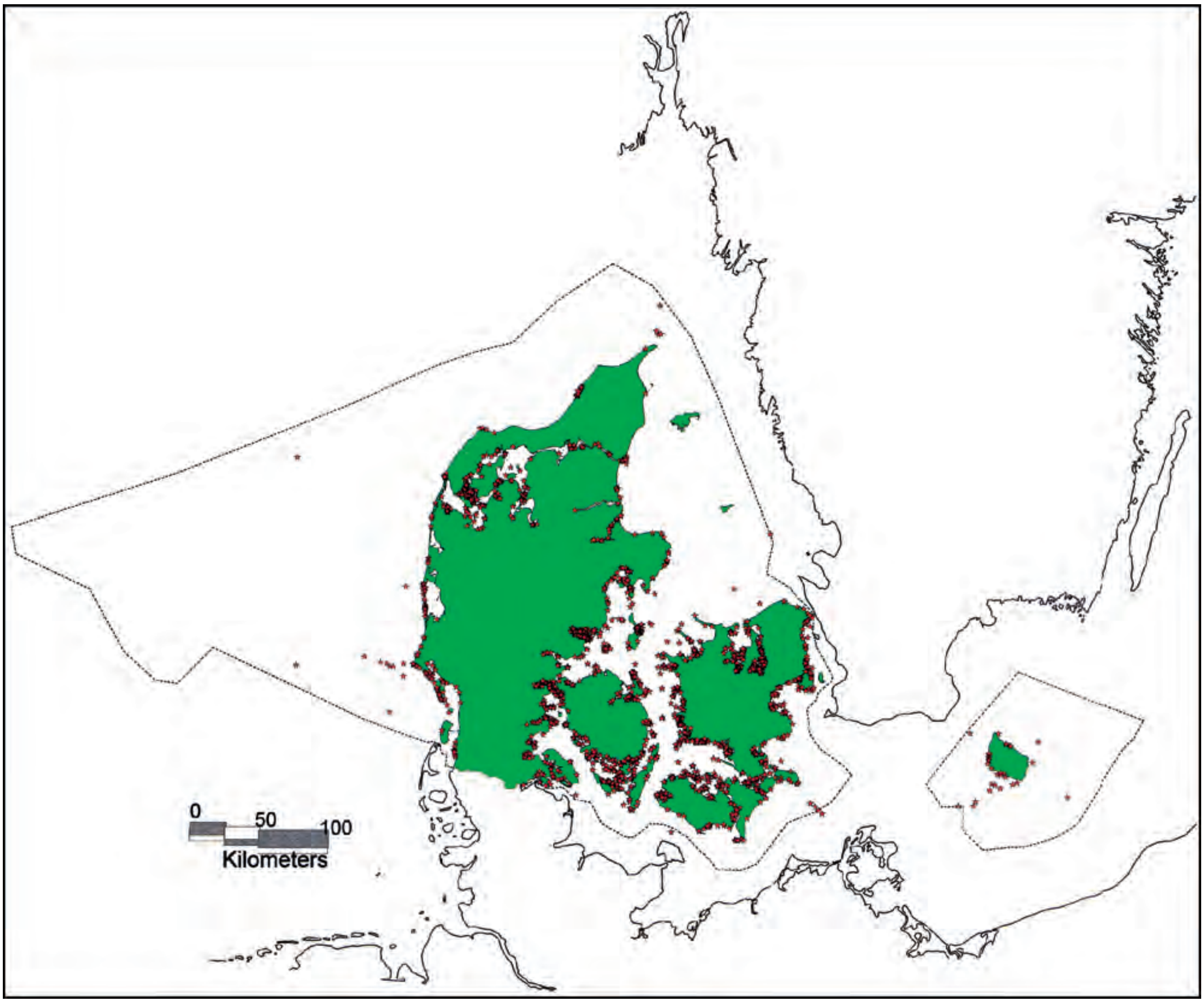


Figure 3.3 The c *2300 prehistoric sites recorded on the Danish sea territory by 1998. The North Sea is represented with eleven stray finds from the sea floor and several more that have washed up on the shore recently (Courtesy: T Malm)*

by the use of topographical models of site location. During these field campaigns we often found two or three new sites a day (eg Fischer 1993a, 1993b, 1997d).

In very many places on the Danish sea floor worked flints are directly visible. This is to a high degree the result of erosion. Breaking waves during the transgression of the sites in prehistoric times have caused part of this erosion. Modern day sea floor erosion has contributed severely too. The latter phenomenon on the one hand strongly facilitates the discovery of cultural remains (Figs 3.4 and 3.5), but on the other hand it causes rapid destruction of the highly interesting organic components of the sites. Down to at least a depth of 10m of water much of our cultural heritage is presently being worn away by waves and currents. This erosion is probably caused by pollution, which kills the underwater vegetation and thus exposes the sea

Figure 3.4 Surface collecting at a coastal settlement, Rønstenen, which was submerged c *6500 BP. The diver presents a piece of worked red deer antler. (Photo T Malm)*

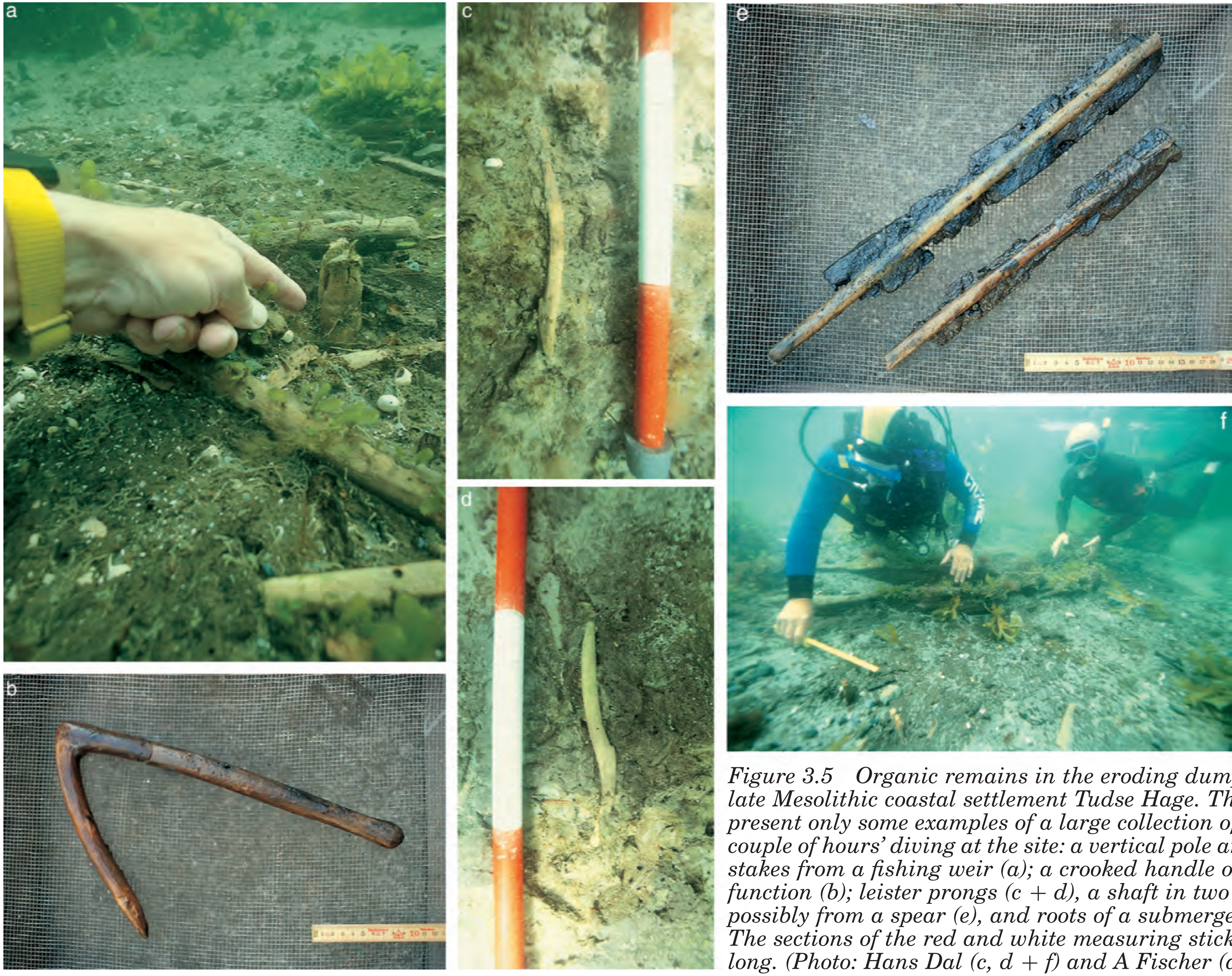


Figure 3.5 Organic remains in the eroding dump area off the late Mesolithic coastal settlement Tudse Hage. The photos present only some examples of a large collection of finds from a couple of hours' diving at the site: a vertical pole and horizontal stakes from a fishing weir (a); a crooked handle of unknown function (b); leister prongs (c + d), a shaft in two fragments, possibly from a spear (e), and roots of a submerged tree (f). The sections of the red and white measuring stick are 20cm long. (Photo: Hans Dal (c, d + f) and A Fischer (a, b + e))

floor. The same problem of the rapid demolishing of hitherto safely buried sites probably exists all along European coasts.

Settlements and graves

Settlements are the most numerous type of submerged site recorded so far. They are primarily defined by the presence of worked flints. The deepest of these sites has been found at *c* 16m below present sea level (Fischer 1997c; cf Dencker 2002). Stray flint has been found as deep down as *c* 20m, and for practical reasons we do not yet have information from areas deeper than that.

It seems that the majority of Stone Age sites on the South Scandinavian sea floor were originally located in the immediate vicinity of large bodies of water — rivers, lakes, and especially the sea. In those days people apparently preferred to live directly by the water's edge. They very often settled along the seashore right next to places where they could exploit fish runs by building stationary fishing structures out from the shore (Fischer 1995a, 1997c; Pedersen 1995, 1997).

At the large South Scandinavian late Mesolithic coastal settlements — above as well as below present sea level — one or more of the following elements is usually preserved to a varying degree:

- A water-deposited dump rich in organic remains such as fragments of wickerwork fish weirs, log boats, discarded tools, and in particular a lot of food remains
- A habitation area with fire places, flint knapping workshops, etc
- Graves, usually located on the upper parts of the sites.

When the sites were submerged they often became subject to erosion from waves and currents. Considering the power of the breaking waves at wind-exposed coasts it is surprising to see how much is actually still preserved. The upper parts of the sites are usually most severely eroded, ie the living area and the graves (Fischer 2001, Fig 3.8). Nonetheless, it is possible to find, for instance, intact fireplaces. An instructive example of this was excavated at the Argus site. It was buried under just a couple of centimetres of sand at a depth of 5m below present sea level (Smed 1987a; Fischer 1987). It consisted of an irregular stone pavement littered with residue from the fire: charred branches forming a star-shaped pattern, lumps of burnt flint, ashes, and small fragments of more or less burnt food remains (Fig 3.6). The latter material tells of a varied diet originating from fishing, hunting, and gathering of plant food (Fischer *et al* in prep b).

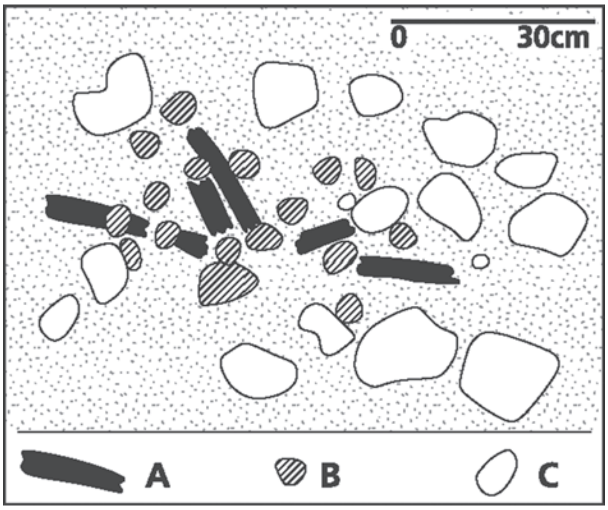


Figure 3.6 A submerged hearth at the Argus site with the remains of the last fire still in place. Charred branches (A), lumps of burnt flint (B), stone pavement (C)

A number of submerged Stone Age graves have also been recorded from the Danish sea floor (Smed 1987b; Schilling 1997; cf Grøn and Skaarup 1993). Figures 3.7 and 3.8 show a submerged grave, dated to 6740 ± 80 BP (K-3558). It was exposed by modern erosion 2.5m below the present water surface, and contained a young woman and her little child (Andersen 1985).

At very many sites parts of the water-deposited dump areas immediately adjacent to the original coastline are preserved. Some of these dumps have been saturated in oxygen-free water ever since their deposition. In such cases they contain very perfectly preserved organic remains, for instance, textiles made of plant fibres, and elaborate wooden artefacts (Skaarup 1981; Andersen 1985, 1995a). Even though they are submerged it is relatively easy to dig these organic deposits, and to make precise recordings of their stratigraphy (Malm 1995).

Stationary fishing structures

Fishing with weirs built of wood has been practised in the Danish archipelago until *c* 1900 AD. Almost identical constructions are known from the Stone Age. The largest one recorded is located perpendicular to the former shore at the small island of Nekselø. It consists of vertical poles up to 150mm in diameter (Fig 3.9). On these poles 4m wide and up to 4m high wickerwork panels were tied. The panels were made of perfectly straight sticks of hazel, produced through large-scale systematic coppicing. This construction, which is being rapidly eroded, is so far recorded over a distance of *c* 250m.

Earlier and smaller versions of this kind of fishing weir have been recorded in several places,

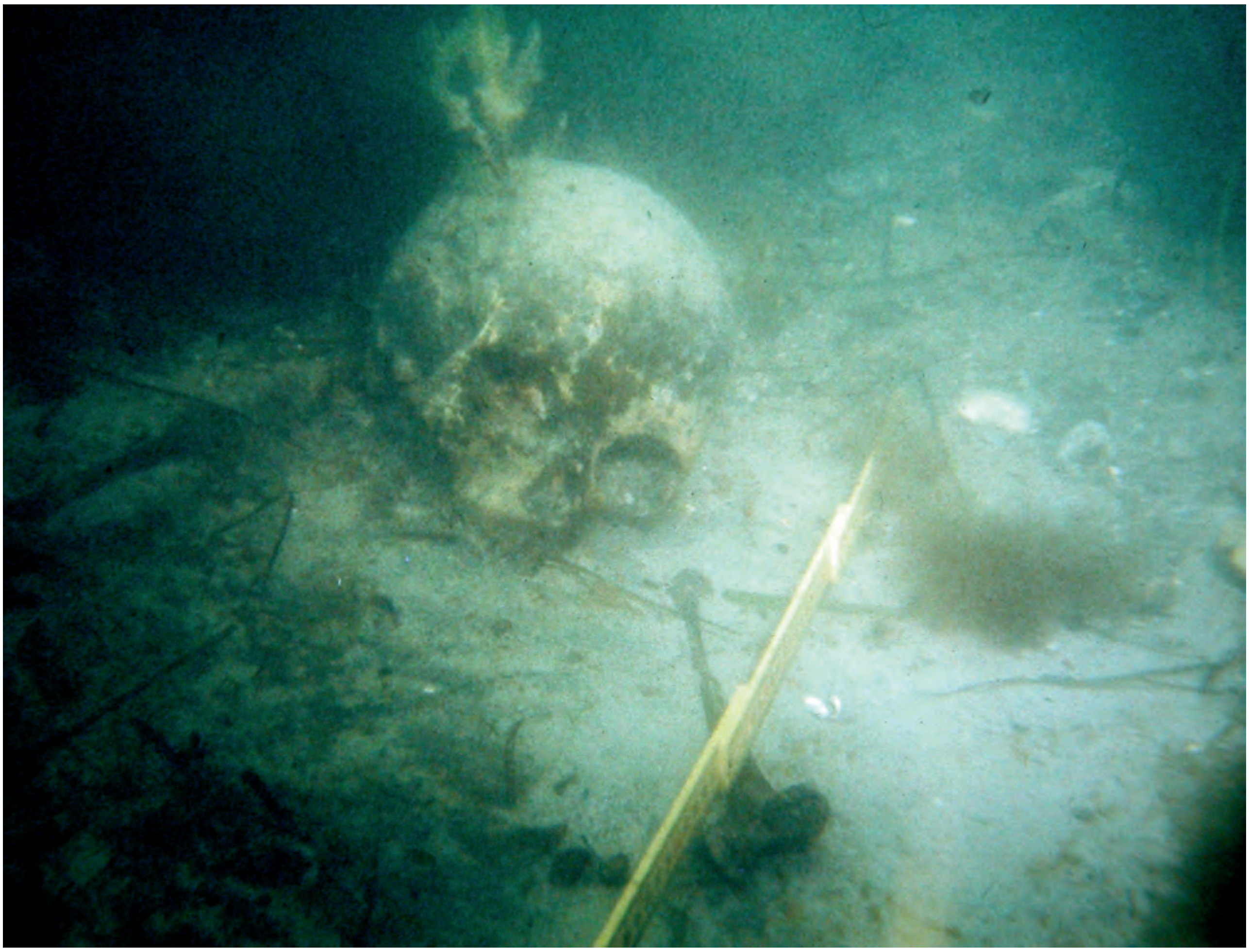


Figure 3.7 The cranium of a young woman in situ *in her submerged grave at the Tybrind Vig site. NB: Muddy waters and well-preserved archaeological sites usually go hand in hand. (Photo: Hans Dal)*

including on the sea floor. The earliest radiocarbon dated example is from 7550 ± 40 BP (AAR-8415), and was found in connection with a marine dump layer off the late-Maglemosian coastal site of Kalø Vig (Fischer 1994, Fischer and Hansen in press).

It appears that each coastal Mesolithic settlement along the shores of the internal Danish waters had one or more fish weirs, which probably had to be repaired and replaced frequently. This implies that stationary fishing structures are probably the most numerously represented type of prehistoric feature on the Danish sea floor, and it may very well be the same on the British sea floor.

Sacrificial sites and stray finds

Votive sites from the Neolithic are common phenomena in the Danish archipelago. Sites belonging to this category are mainly found close to the present shores, typically in protected areas such as fjords and narrow straits. At these sites precious artefacts have been deposited deliberately — much in the same manner as at the votive sites in lakes and mires in the south Scandinavian inland. The types of finds most frequently seen on the submarine votive sites are late Neolithic flint daggers (eg Fig 3.10c, 3.10d), but flint axes, shaft-hole axes and pottery are also often seen (Davidsen 1983).

Stray finds constitute another richly represented archaeological category from the Danish sea floor. They typically consist of items lost at sea such as bone fish hooks and antler harpoon heads. Among the more spectacular artefacts is a ceramic vessel reminiscent of Roman *terra sigillata.* It was found in the North Sea 60 nautical miles west of the port of Esbjerg (Fischer and Sørensen 1983).

Submerged forests

One of the surprises from archaeological surveys of prehistoric remains on the sea floor is the many well-preserved stumps of trees, which have

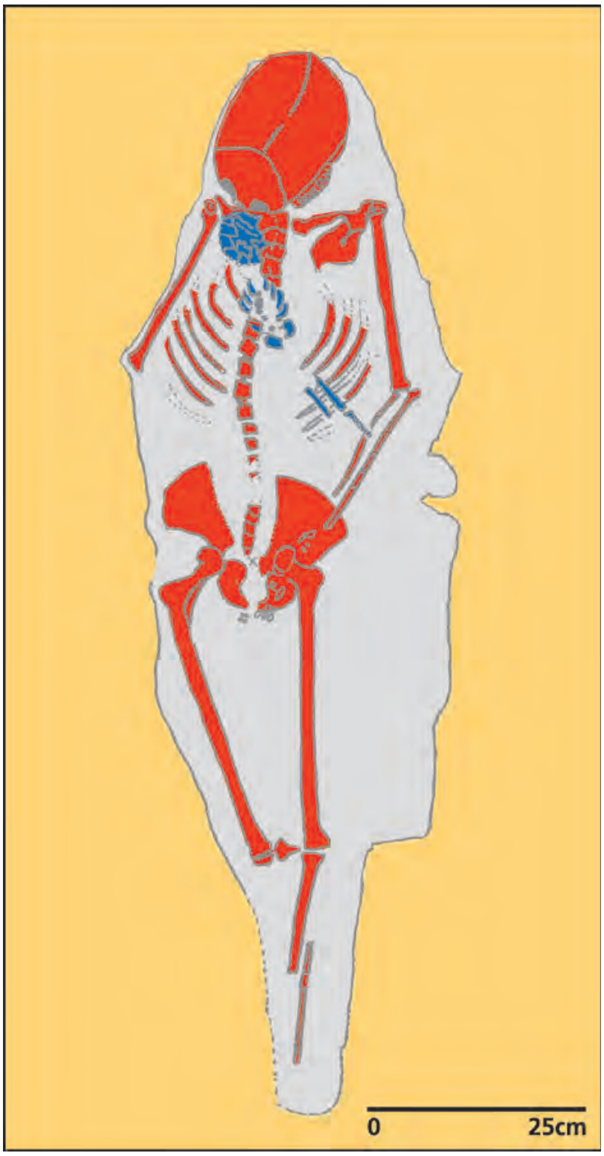


Figure 3.8 The Mesolithic Tybrind Vig grave with mother and child. (Redrawn from Smed 1987b)

Figure 3.9 Vertical poles from a Neolithic fishing weir, exposed by rapid sea-floor erosion. The red and white sections of the vertical measuring stick are 20cm long. (Photo: A Fischer)

been found rooted at their original living-place (Fischer 1997a). They often stand as close together as the trees in a present-day forest (Fischer and Malm 1997). Usually the stumps are only preserved from the level of the former land surface downwards (Fig 3.11). There are, however, well-documented examples of rooted trees standing with vertical trunks to a level of more than a metre above the original land surface, although now covered by later layers of water-deposited sediments.

The stumps on the sea floor seem in most cases to represent trees that died, were buried and preserved as a consequence of the rising sea level. So, when swimming up the slopes of the Danish sea floor, divers pass the stumps of progressively later forests. This has been demonstrated by radiocarbon-dated stumps from various depths (Fischer 1995a, 1997a; Sørensen 1996, 94). Using these and other radiocarbon-dated samples collected during underwater archaeological surveys, highly detailed information on the global sea-level changes during the Holocene has been obtained (Fischer 1995a, Christensen *et al* 1997, Fischer and Hansen in press). On this basis it has been determined that between 7000 and 6200 BC (calibrated) the sea level rose from around 27m to 9m below present sea level, implying an average rise of 2.3m per hundred years. This average probably conceals shorter intervals of much more dramatic transgression, since the pace of global sea-level rise apparently varied as a result of cyclic climatic variations.

The archaeological purpose for recording this type of environmental data is double:

- The stumps inform us that the original land surface is well-preserved at that place. Settlements in the same area should, therefore, probably also be well-preserved
- Trees are usually killed by the transgressing sea, and when radiocarbon-dated they provide us with first-class information on the local shoreline displacement process, which is of relevance when predicting site locations with topographical models.

In Danish waters submerged forests are at present recorded down to a depth of *c* 30m (Figs 3.11 and 3.12). The oldest ones date back to *c* 9000 BP. Even older ones are surely to be found much deeper, if we start looking for them in the North Sea (cf Reid 1913, 39ff). The presence of such tree stumps have been indicated by seismic surveying in a filled-in river valley at a depth of 45–50m in the eastern end of the Dogger Bank (Hansen 1981, 18–19).

Figure 3.10 *Examples of Neolithic votive artefacts from the Danish sea floor: off Fredrikssund (a), Musholm Bay (b), Fur Sund (c), and off Hensingør (d). (Photo: N Elswing (a), K Petersen (b), K Weiss (c), and L Larsen (d))*

Figure 3.11 A stump of an oak tree in situ *at a depth of 2m in Kalundborg Fjord. Dated to 6835 ± 55 BP. (Photo: A Fischer)*

Topographic models

The Danish experience tells us that Mesolithic coastal settlements were usually located on the beach directly above good places for fishing with weirs as for instance at narrow straits and at the mouth of rivers (Fischer 1993a). These observations have been integrated into 'the fishing site model' (Fig 3.13).

In those places where little later erosion or sedimentation has taken place, the depth contours on the maps of the sea floor represent shorelines during various parts of prehistory. Therefore the topographic model often works well in combination with ordinary commercial maps of the Danish sea floor. For instance the inspection in the Småland Bight of 26 predicted settlement sites (Fig 3.14) resulted in the recording of thirteen sites with regular remains of Stone Age habitation and a further eight sites with indications of Stone Age habitation at the spot or in its immediate vicinity (Fischer 1993a). We have also had very fine results from the application of the fishing site model in combination with maps made by means of seismic surveying in areas covered with more recent sediments of sand and gyttja.

Experience based on the location of late Palaeolithic and earliest Mesolithic coastal settlements at raised beaches in Norway and Sweden indicate that other topographical models ought to be elaborated and tested too. In the development of models for predicting the location of such very early and highly marine-oriented coastal settlements it appears most obviously from the Norwegian and Swedish evidence to focus on topographic features favourable for boat-landing and whale-hunting.

Figure 3.12 These two 10,000-year-old stumps of pine trees were found at a water depth of 30m. They still smelled strongly of resin when radiocarbon samples were cut from them. (Photo: S Madsen, A/S Storebælt Fixed Link)

Discussion

The submerged Stone Age settlements are important for at least three reasons:

1 Their special preservation qualities for organic materials
2 They constitute major parts of the settlement patterns in coastal regions. No serious estimates on late Pleistocene and early Holocene human population size and distribution can be obtained without knowledge of the coastal habitation, which is now to be found on the sea floor in most parts of the world
3 They appear to represent a more varied array of subsistence, manufacturing, and ceremonial activities than the inland sites from the same regions.

δ^{13}C values of many of the bones of humans and dogs found at Danish inland sites testify close connections between the coast and inland all through the Mesolithic (Fischer 2003, 2004; (Fig 3.15)). The same applies to the southern part of Sweden (Lidén *et al* 2004) and to eastern England too, as illustrated by finds from the Vale

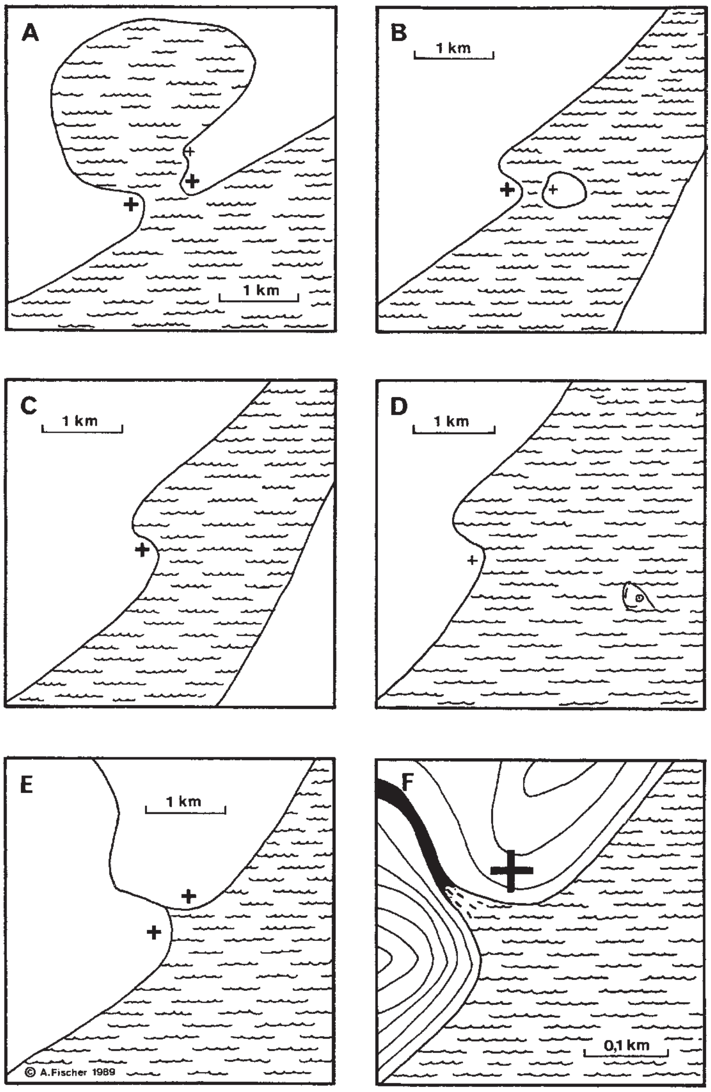


Figure 3.13 Exemplification of settlement locations according to the fishing site model

of Pickering in Yorkshire (including the Star Carr site). From this English bog two early Mesolithic dog bones have δ^{13}C-values, which imply that these animals have been eating a lot of marine food (Clutton-Brock and Noe-Nygaard 1990; Schulting and Richards 2002). Since such food was not available inland, where they ended their lives, these individuals must have spent much of their lifetime at the coast. Consequently early Mesolithic coastal settlements must have existed along the now submerged coastlines in the English part of the North Sea.

In Norway and western Sweden coastal settlement has been traced further back in time than anywhere else in Northern Europe. Thanks to isostatic land rise, early Holocene as well as late Pleistocene beach lines are now above sea level in this region and are thus easily accessible to archaeological survey and excavation. From the archaeological exploration of these raised beaches it transpires that the sea coast was the focal area of habitation in this region at least as far back as approximately 10,000 BP — that is, the transition between the Pleistocene and the Holocene (Bjerck 1995; Kindgren 1995, 2002; Schmitt 1995; Prösch-Danielsen and Høgestøl 1995; Bang-Andersen 2003; cf Nordqvist 1998).

The same archaeological situation may exist below present sea level in the Scottish part of the North Sea region. This hypothesis seems to find support in the existence of a stray find of a tanged point from the west Scottish archipelago (Morrison and Bonsall 1989). Morphologically it seems to be very similar to the arrow points found in the final Palaeolithic/earliest Mesolithic (Ahrensburgian) assemblages of, for instance, south-west Norway and west Sweden.

The well-drained sand and gravel deposits characterising the earliest settlements on raised

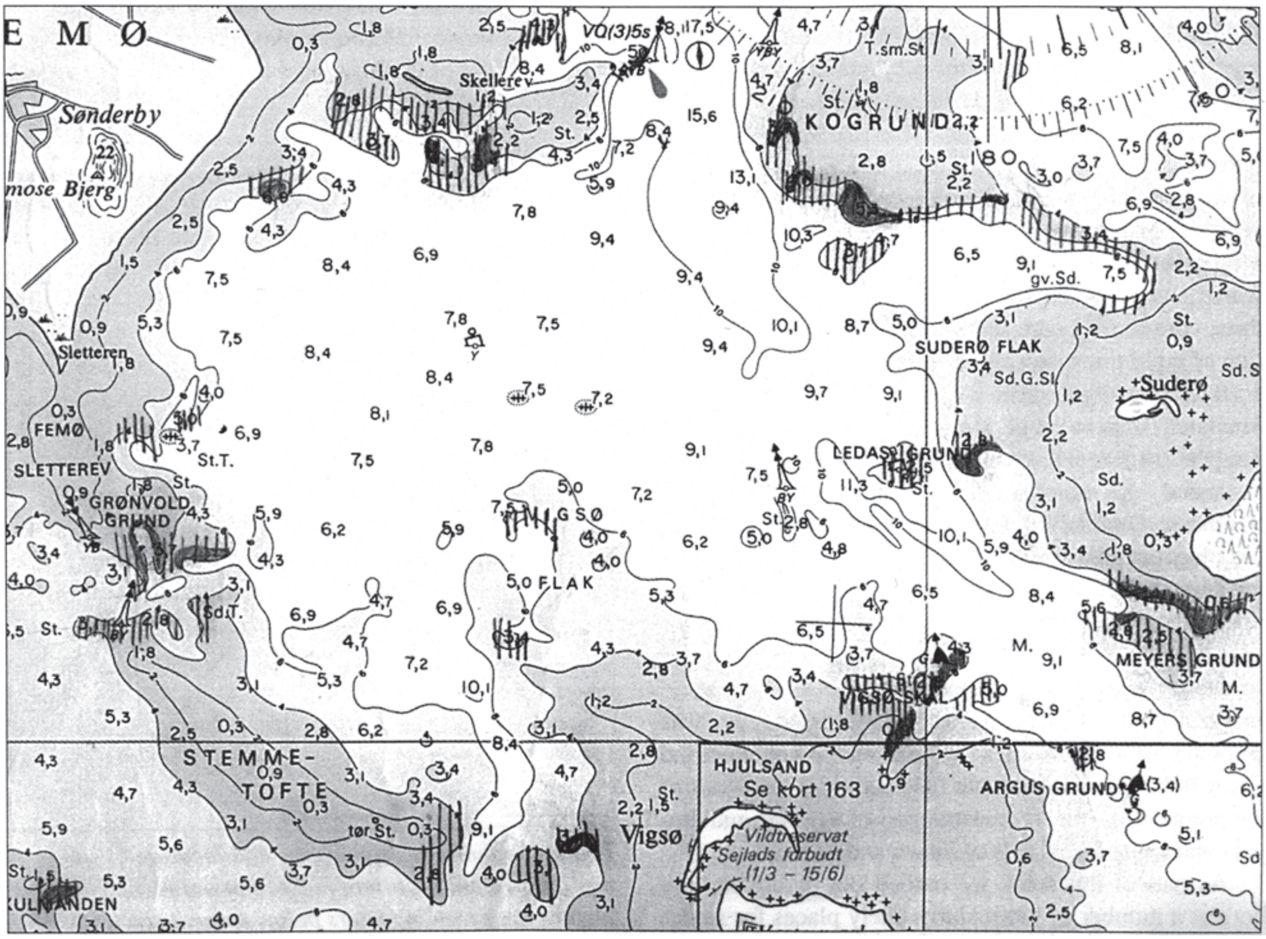
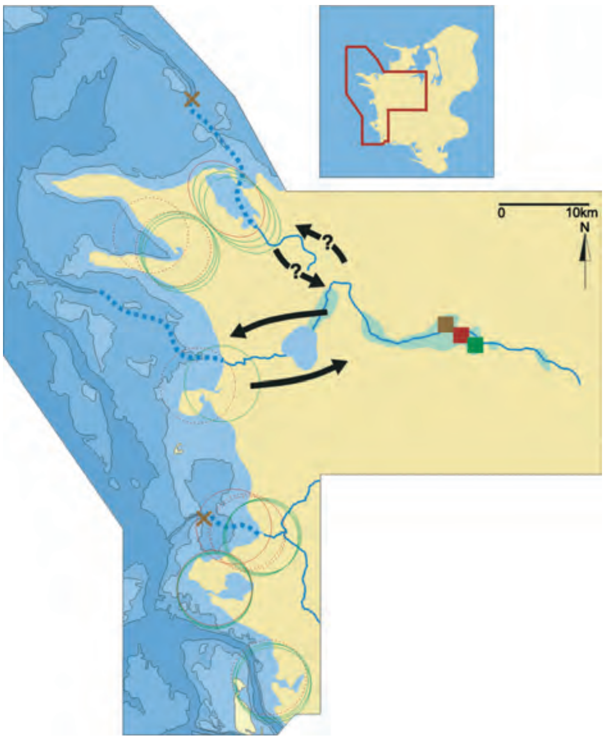


Figure 3.14 The fishing site model applied to a modern map of the Småland Bight



beaches in Sweden and Norway have relatively little potential for the preservation of organic materials. Therefore, there is not much direct information available on the economic basis of these coastal sites. Their topographical setting does, nonetheless, give hints as to their subsistence (Bjerck 1990; Kindgren 1995, 2002). Since they were typically located in the outer archipelago — often on islets in the open sea — the inhabitants of these sites can hardly have lived on anything other than marine resources: whale, seal, and fish. From the topography of the sites it appears that the early inhabitants of this northernmost region of Europe were highly dependent

Figure 3.15 Clusters of middle and late Mesolithic settlements (circles) along the Storebælt, Denmark. Habitation gradually moved up the slopes with the rising sea level. At the same time there were small seasonal sites in the interior (squares). Maglemose Culture (yellow), Kongemose Culture (red), Ertebølle Culture (green). (Drawing: B Nielsen) on boats. Thus, they probably arrived to these regions sailing along the coast, not walking over land, as has been thought for generations.

The first pioneers of the Scandinavian Peninsula seemingly arrived already well-acquainted with life on the coast. We may, therefore, safely assume that coast-adapted societies had existed long before, along the now-submerged sea shores of the North Sea and even further away along western and southern Europe.

Measurements of stable isotopes in 'the Red Lady of Paviland' from the southern coast of present-day Wales indicate that around 10–15% of this individual's dietary protein derived from the sea. It is dated to *c* 26,000 BP (Richards *et al* 2001).

The Upper Palaeolithic record from the south-west European inland regions includes many indications of the existence of intense coastal activity during that age (Fischer 1996a). Perhaps

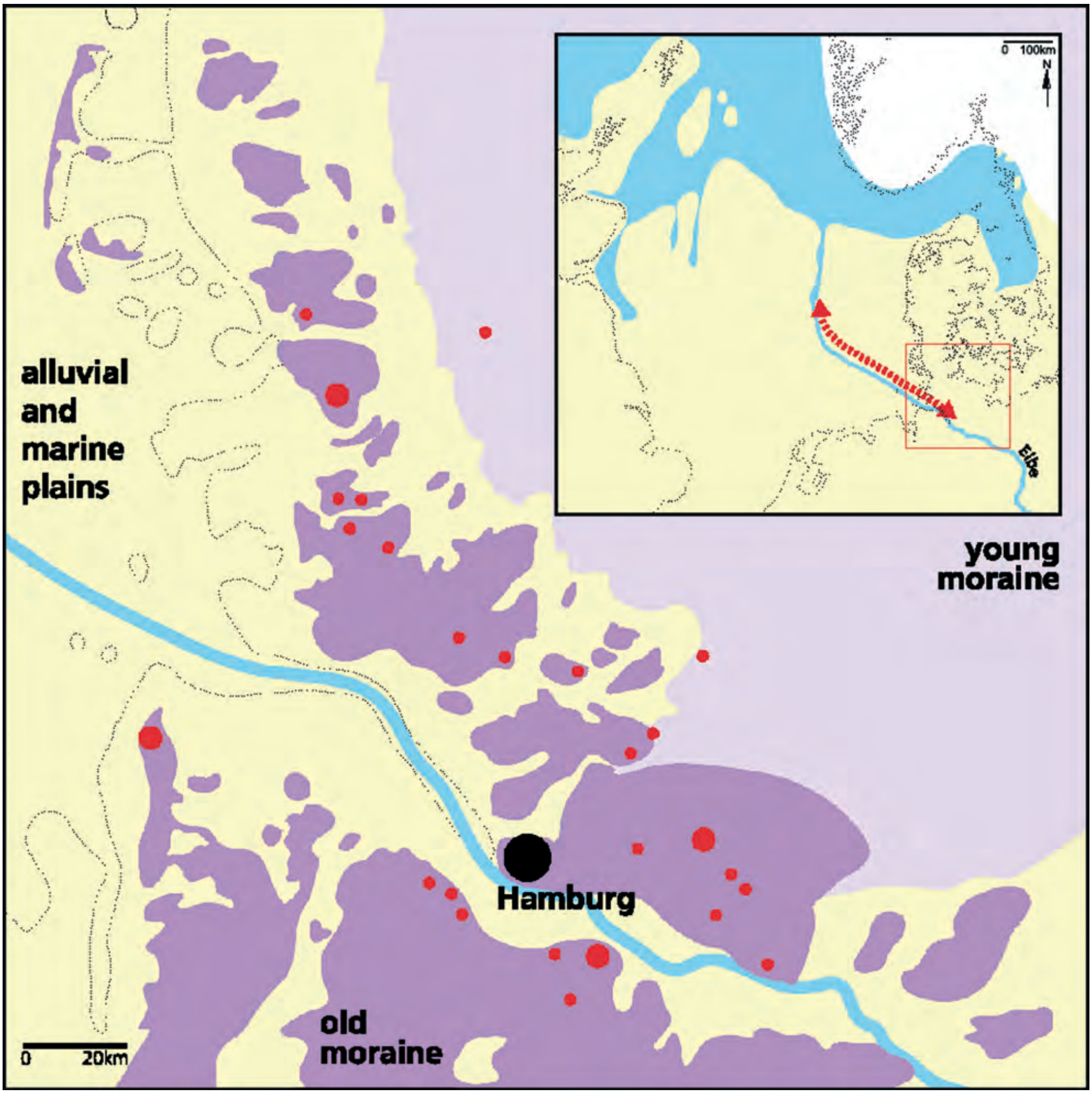


Figure 3.16 The remarkable cluster of late Palaeolithic hunting camps (red dots) from the Hamburg Culture in the region around present-day Hamburg may be seen as part of a settlement pattern, which was mainly focused on the coast. Most of the way to and from the reindeer hunting camps in the inland transportation may have taken place by means of boats. (The map is party based on Lambeck 1995, Bratlund 1996, and Coles 1998) Yellow = alluvial and marine plains; pale purple = young moraine; dark purple = old moraine

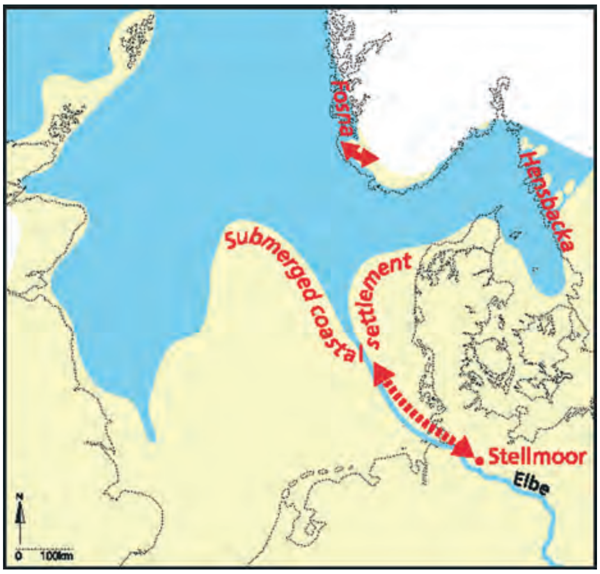


Figure 3.17 A model of the settlement pattern in the eastern North Sea region c *10,000 to 9500 BP: coastal habitations were supplemented with seasonal reindeer hunting camps in the interior. Transport between these areas followed the river systems, and probably took place by means of boats as far as possible. The Ahrensburgian coastal habitation is well-documented in Norway and west Sweden, where it is traditionally termed Fosna Culture and Hensbacka Culture respectively. (The map is partly based on Lambeck 1995, Coles 1998, and Bang-Andersen 2003)*

the dense cluster of late Palaeolithic sites in the Hamburg region may actually be an indication of the existence of coastal habitation similar to the one known from Norway in the initial Holocene. Recent investigations in the inland of south-west Norway have demonstrated the existence of small reindeer hunting camps in the more elevated parts of that region. They are, no doubt, seasonal satellites of larger sites at the coast, and commuting between coast and inland probably took place along the water courses (Bang-Andersen 1990, 2003).

The many sites from the Hamburgian and Ahrensburgian Cultures (*c* 12,500–12,000 and *c* 10,000 BP respectively) in the region around the city of Hamburg also represent seasonal camps specialised in reindeer hunting. They are usually found at positions which seem to have been ideal for drive hunting of seasonally migrating herds of reindeer (Grønnow 1987; Bokelmann 1991; Bratlund 1991). Most of the Hamburgian sites are located in the hilly old moraine landscapes above the alluvial plains of the last glaciation (Fig 3.16). They are typically found at the upper reaches of watercourses connected to the huge river Elbe (Bratlund 1996). In the eyes of a coastal population living along the estuary of the Elbe, the location of these inland hunting camps may have been easy to describe: 'move up the river valley until the monotonous lowland comes to an end. Then turn left or right up into the hills along one of the minor water courses until you meet a reindeer migration route' (Fig 3.16 and 3.17).

Conclusion

Submerged Stone Age sites on the Danish sea floor are:

- Numerous
- Often surprisingly well-preserved
- Often technically within easy reach
- Often easily predicted topographically.

In addition they do in many cases represent fundamental aspects of culture, the traces of which cannot be found above present sea level.

This conclusion applies to the submerged Mesolithic settlement on the bottom of the generally shallow and wind-protected waters of the Danish archipelago. Most probably the same will apply to the traces of Palaeolithic and Mesolithic habitation on the bottom of the North Sea.

In general the North Sea has greater depths, larger waves, and perhaps thicker deposits of later sediments than the internal Danish waters. Archaeological inspection by diving will thus be more demanding in terms of equipment, as well as competence. On the other hand parts of the North Sea have depths which are within reach by the relatively simple methods and equipment hitherto applied in Danish waters. Off the eastern coast of England and Scotland there are, furthermore, large areas that are protected from large waves most of the year. So, there is really no technical excuse for not getting started.

Professional underwater archaeology in the deeper and more wave-exposed parts of the North Sea will be highly specialised work and will demand expensive and specialised equipment. When engaging in that kind of activity it will obviously be beneficial to organise work internationally — in all parts of the North Sea — and further afield.

A realistic impression of Upper Palaeolithic Europe may probably only be gained through studies including sites that are now hidden under the sea. If we want to know how culture and society developed during that age, the submerged coasts are obviously some of the most relevant places to explore.

The 'cradle' of mankind need not have stood in interior Africa. It may just as well have stood at a sheltered African coast, where a diversity of marine, freshwater, and terrestrial biotopes would have secured a uniquely stable and productive subsistence base. The same kind of environments may very well have been the ‘nursery’ of the culturally and socially complex societies that appeared on the scene during the Upper Palaeolithic. Most of those coastal areas are now submerged, and therefore, underwater archaeology seems highly relevant for the study of the formation of early humanity.

4 The inundated landscapes of the western Solent *by Garry Momber*

Abstract

Archaeological investigation in the western Solent utilising divers and geophysical survey data has led to the discovery of Mesolithic occupation sites 11m below British Ordnance Datum. Sites have also been located between 6.5 and 8m underwater eroding from a basal land surface as the covering deposits diminish. The sites were discovered following systematic search and survey. A project undertaken by the Hampshire and Wight Trust for Maritime Archaeology and sponsored by English Heritage is interrogating the submerged landscape to help interpret the geomorphological evolution of the submerged coastline with particular reference to human impacts.

Introduction: identifying the need for research into the archaeological and palaeoenvironmental resource

The potential for submerged forests and peats has been identified in *England's Coastal Heritage: A survey for English Heritage and the RCHME*. It notes that selected exposures 'would provide a framework both for the monitoring of erosion and for the recording of new discoveries' (Fulford *et al* 1997). The importance of submerged peat deposits is emphasised in *Taking to the Water: English Heritage's initial policy for management of maritime archaeology in England* where research into this resource is a stated priority (Roberts and Trow 2002).

A fundamental dichotomy exists between the potential for archaeology in submerged stratified deposits and the archaeological potential of particular sites. We know that archaeological material survives well in submerged peat and silt deposits and its discovery can produce far-reaching insights into past cultures. What we do not know is where to look within the deposits which may be inaccessible and extensively distributed. This is not so much of a problem on land where chance discoveries as a result of natural erosion or development may be witnessed and action taken to record the finds. Underwater, where large tracks of peat and Holocene sediments are being exposed and eroded, few eyes are around to record the losses. If we wish to identify the archaeology within these deposits we will need to improve our understanding of the landscapes in which they were laid down to increase our chances of locating sites of human occupation. The work currently underway to assess the palaeoenvironment associated with archaeological sites, with the support of English Heritage, is looking to address these issues and help define the value of the archaeological and palaeoenvironmental resource.

Investigations in the Solent

The Solent is the waterway that separates the Isle of Wight from mainland Britain and for thousands of years it has been a major maritime route into England from the south. The shelter afforded by the Isle of Wight has aided the preservation of submerged deposits laid down throughout the Holocene. These deposits form a rich sediment archive; they also have a high preservation potential and are host to a rich source of archaeological material.

The areas being studied include large tracts of exposed peat deposits within a submerged landscape off Bouldnor Cliff along the north-west coast of the Isle of Wight (Fig 4.1). These sites are the source of prehistoric archaeological material. Excavations in 2000 and 2003 identified the source of Mesolithic lithics from a deposit immediately below a submerged forest dated to 8565–8345 cal BP (Beta-140104).

Insights into the formation of the Solent

The origins of the Solent can be traced back into the Pleistocene where river systems abraded a path across the southern part of the Hampshire Basin from Dorset through to West Sussex. Numerous academics have discussed the evolution of the 'Solent River', a principal drainage route from the Hampshire Basin (Fox 1862; Everard 1954; Allen and Gibbard 1993). The primary source of information for these studies had been the fluvial deposits laid down as the river migrated south. However, recent seismic and coring investigations in Southampton Water and the eastern Solent (Hodson and West 1972; Dyer 1975) have helped to define the course of palaeochannels (Fig 4.2).

A channel identified as the Solent River has been recorded running from about 20m below OD in the east Solent, down to 45m below OD east of the Nab Tower. This would have been a main tributary of the Channel river system that existed during glacial periods of the Pleistocene.

Figure 4.1 Solent showing Bouldnor Cliff excavation site indicated

Consequently it is an area rich in gravel deposits; it is also rich in peat formed during and ahead of the Flandrian Transgression as the rising sea levels worked up the estuaries and river systems (Long and Tooley 1995). To the west, research has recently identified a series of south-flowing palaeo-valleys which breached the old 'Needles to Handfast Point' chalk ridge prior to the Flandrian Transgression (Velegrakis *et al* 1999; Velegrakis 2000). This evidence challenges the notion of a Solent River passing from west to east, north of the Isle of Wight during or following the last glacial epoch. By contrast there would have been a system of channels draining the higher lands directly to the north and south, possibly forming two separate waterways running east and west of the island.

In the western Solent, the course of a palaeo-channel has not been satisfactorily detected. This is primarily due to erosion which continues in the system as it is evolving (Tomalin 2000a). Large deposits of the early to mid-Holocene landscape do however fringe the waterway. These represent a rich archive of sediments and peat that contain archaeological material. However, as the Solent continues to evolve, the Holocene deposits are now being exposed. The loss of the resource is of great concern but it has presented the opportunity for research into the geomorphological evolution of the waterway and its relationship to archaeological material.

Recent studies of these deposits as part of a European LIFE report have recognised their value as a resource to interpret past geomorphological, environmental, and archaeological change through time (Dix 2000; Momber 2000a; Scaife 2000; and Tomalin 2000b). The report detailed

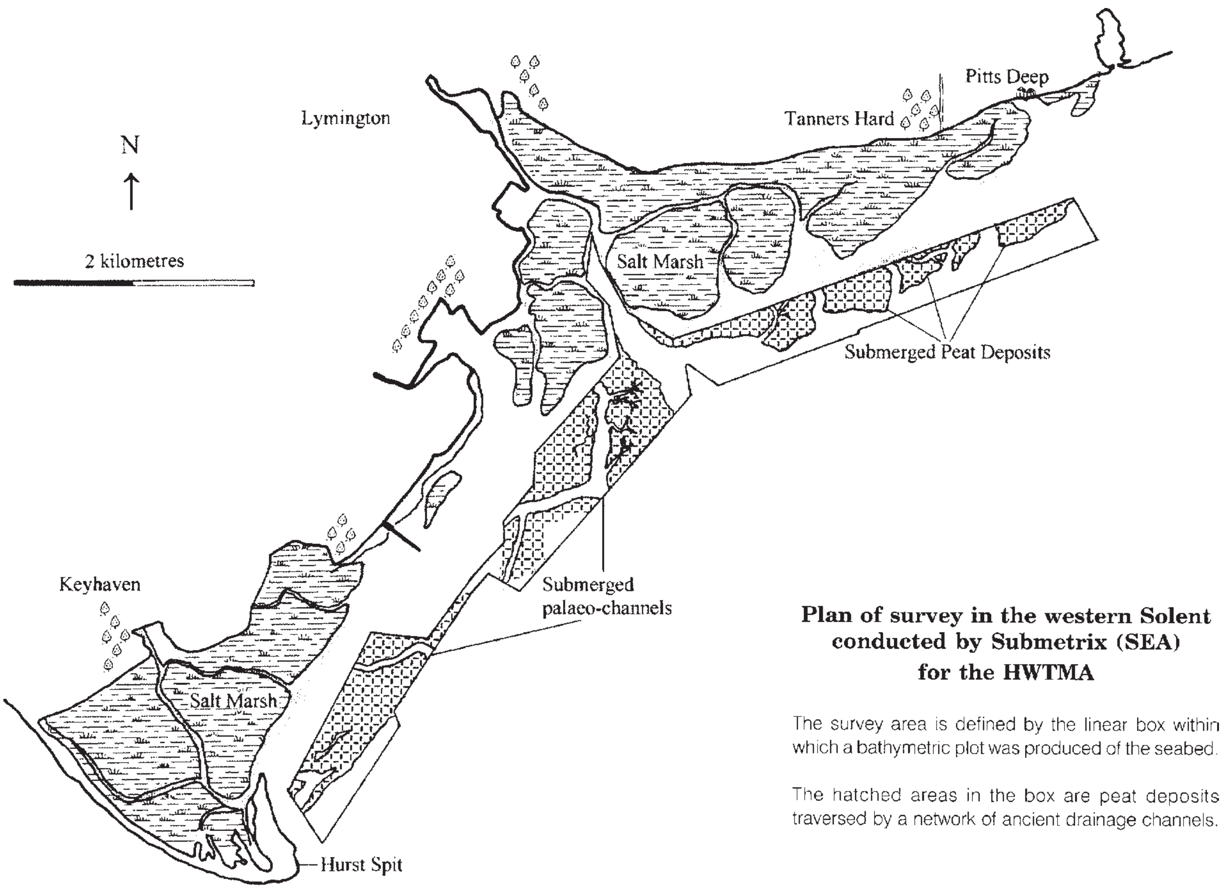


Figure 4.2 Image generated from bathymetric data showing submerged landscape exposed due to loss of mud flats along north-west Solent

work on the north coast of the Isle of Wight. It demonstrated a high archaeological potential both above and below water. A notable example is the underwater cliff off Bouldnor which hosts the Mesolithic site 11m below OD (see below) (Momber 2000b). A rich archive of palynological information in the coastal sediments of the submerged rias at Ranleigh Spit in Wootton Creek and at the mouth of Newtown Creek was also identified.

The current archaeological and palaeoenvironmental evidence suggests the transition of the Solent to a fully marine environment began somewhere around 5500 BP (Tomalin 2000a), while geophysical evidence suggests 7000–7500 years ago (Velegrakis 2000). The ongoing erosive processes within the system would suggest this transition is not complete and a stable equilibrium has yet to be reached. An understanding of these processes is an essential basis upon which informed future predictions of coastal change should be founded (Tomalin 2000a).

Human exploitation of the coastal margins

A relatively short-lived interstadial towards the end of the last Pleistocene glaciation heralded the arrival of the Upper Palaeolithic to the south coast of England. The land the new migrants found had a coastline many miles from the one we see today. The late Upper Palaeolithic site (12,500 ± 1150 years BP (OXTL 707a)) on the coastal peninsular of Hengistbury Head, Christchurch Bay was home to seasonal hunters who occupied a small hill overlooking plains to the south (Barton 1992). The site was reoccupied during the early Mesolithic (9750 ± 950 years BP (OXTL107c)) (Barton 1992). The period between occupations was punctuated by the final stadial of the Pleistocene. As this drew to a close and the Holocene began, the warming climate encouraged greater levels of human migration north.

The early Mesolithic occupants of Hengistbury Head would still have looked over plains and valleys to the south, but these were steadily subject to forestation before becoming totally inundated during the next 4000–5000 years. Unlike during the Upper Palaeolithic when activities on the higher ground, currently above sea level, appear to have been curtailed by the onset of the final cold stadial, the Mesolithic people remained in Britain. As hunter gatherers, they would have found the most protein rich diet near the coast (Momber 2000b; Simmons 1996; Pedersen 1997). This has been demonstrated along the coastlines of Denmark and southern Sweden where occupation sites during the sixth and fifth millennium BC were three times as numerous in areas with access to the shoreline than those inland (Rowley-Conwy 1983). Along the south coast of Britain, few Mesolithic coastal sites have been found, but as the coastline was in continual retreat during the period this should not be surprising. Indeed, the areas most exploited between *c* 10,000 and *c* 6000 BP remain at the bottom of the intertidal zone or several metres beneath the water.

Archaeological evidence of occupation in the Solent

Many artefacts have been found in the Solent which have shown it to be very rich in prehistoric archaeological material. Unfortunately, most of these have been trawled up by fishermen and been recovered out of context (HWTMA 2000a; Sparks *et al* 2001). Modern erosion at Wootton and Quarr beaches revealed archaeological material ranging from the Mesolithic to the post-medieval period. Here, a survey was funded by English Heritage and carried out by the Isle of Wight Archaeological Unit during the 1990s (Tomalin 1993; Loader *et al 19*97). Comparable evidence was uncovered in Langstone Harbour on the north-east of the Solent during the Langstone Harbour Project in the 1990s, thereby testifying to the geographical diversity and archaeological potential of the submerged and intertidal resource (Allen and Gardener 2000).

Along the north-west shores of the Solent, salt marsh has been eroding rapidly. As the mud flats are lost, areas of peat and submerged forest have become exposed on the sea floor at 4m below OD. This deposit averages approximately 500m wide and is evident for over 8km mirroring the coastline. At points along its seaward perimeter, it terminates in a small cliff. At the foot of this cliff, a further peat outcrop is visible. This lies at −5.5m to −6m OD. The intervening sediment appears comparable with that at Bouldnor. Samples from the bases of both peat deposits have been radiocarbon-dated to 6420–6190 cal BP (Beta-166477) and 7240–6890 cal BP (Beta-166478) respectively. Many Mesolithic and Neolithic lithics have been recovered by oyster trawlers from the surface of the seabed following erosion of the peat. Depletion of the mud flats can be calibrated against charts dating from 1781. As they are lost, the submerged landscapes become exposed and erode, shedding their archaeological contents.

Mesolithic archaeological material, 11m below Ordnance Datum

Along the southern coast of the western Solent, a submerged cliff of Holocene silts running parallel with the foreshore for over a kilometre protects the remains of a submerged landscape containing large oak timbers and matted vegetation. Here, three outcrops of peat at −4m, −5m and −11 to 12m OD are evident. The bases of these deposits have been radiocarbon-dated to 6475–6280 cal BP (Beta-140102), 6870–6485 cal BP (Beta-140103) and 8565–8345 cal BP (Beta-140104) respectively. The intervening materials are unconsolidated, brackish alluvial sediments.

At the foot of the submarine cliff, artefacts dating to the Mesolithic were identified in 1999 and 2000 (HWTMA 2000b). The discovery was made when an area of exposed seabed was visually inspected. Lithics were found lying on the surface of the seabed following burrowing activity by lobsters which had removed the archaeological material from its context. Large oak trees lay within the peat adjacent to the burrows. Sections of trees have been recovered for dendrochronological analysis by Nigel Nayling. They have provided a floating sequence of 280 years dated to around 8565–8345 cal BP (Beta-140104).

In May 2000 a small trial trench was excavated. Archaeological material was recovered from an organic sandy deposit directly below the basal peat deposit at −11m OD. The excavation revealed over 300 worked and burnt flints (Momber 2001). An extended trench in May 2003 has exposed more of the site. This has revealed detailed stratigraphy and enabled the collection of monolith samples (Fig 4.3 and 4.4). The work is currently being processed but additional worked flints have been recovered from both the known archaeological horizon identified in 2000 and from an apparent Devensian outwash deposit directly to the east. Half a kilometre to the west another site was investigated. This was sampled and surveyed. It was also the source of archaeological material recovered from 6.5–8m below Ordnance Datum.

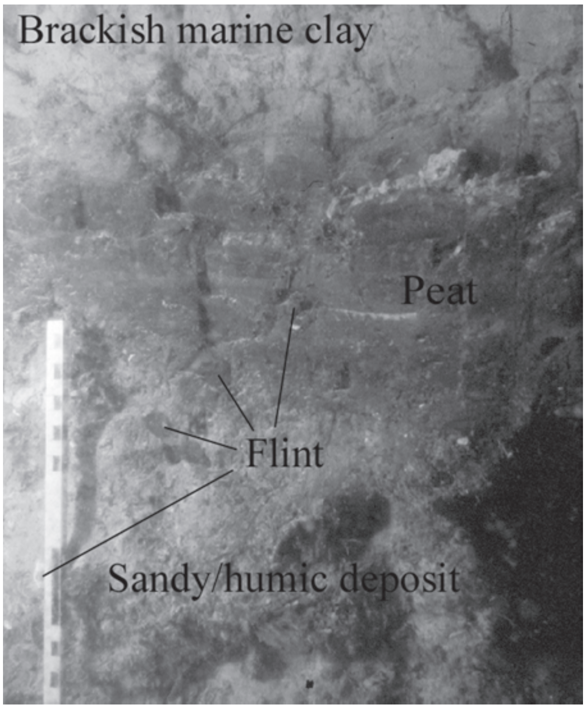


Figure 4.3 Section across horizon containing cultural material. Lithics have been recorded from within and below the peat deposit

Figure 4.4 Lithics recovered from Bouldnor Cliff site

Additional timber samples were collected to enhance the dendrochronological record compiled in 2000. Degradation of up to 600mm was recorded in the timbers that had been sampled only three years earlier. The main cause of erosion is believed to be biological attack brought about by marine boring organisms. When the timber is sufficiently degraded it breaks up and is cleared from the site by tidal action.

Assessment and management of an archaeological landscape

The nature and threat to the resource has been identified by the Trust, which, over the last three years, has initiated a trial programme of monitoring and sampling. The pilot programme has introduced the following methodology:

1 Bathymetric and geophysical survey to locate topographic variations and sites of potential archaeological or palaeoenvironmental interest
2 Diver investigation (ground-truthing) to verify the qualitative images produced by the geophysical survey
3 As appropriate, sites are selected for further monitoring or sampling and possible excavation.

(Areas selected have been the edges of underwater cliffs, where the peat deposits are subject to erosion, revealing the palaeoland surfaces)

4 Monitoring recession of deposit both horizontally and vertically using fixed reference points
5 Several forms of sampling are utilised:

- A 30mm auger is used to track submerged deposits under the alluvium
- Hand saws and underwater chainsaws have been used to collect samples of tree trunk for dendrochronological dating and analysis
- Monoliths have been extracted containing samples for palaeoenvironmental analysis.

6 Excavation is considered if necessary to answer questions unanswerable by less intrusive methods.

Targeted archaeological discoveries

A significant discovery towards the western extremity of the Holocene sediments resulted from diver inspection when employing the above methodology. Here, the clay and peat deposits appear to be thinning. As they thin and disappear they expose the underlying basal deposit which rises from −11m below OD, outcropping along a line travelling at an angle up the slope of the cliff from *c* −8m to −6.5m OD.

The importance of this deposit is compounded by the discovery of a lithic scatter *c* −7m OD in 2002, exposed on the basal clays about 1m below the line of peat regression. Visual inspection suggests the archaeology is lying on an early Holocene deposit that predates the Flandrian transgression. It is hypothesised that the flints would have originated from immediately below the peat/humic material which has now eroded. It is also suggested that the organic deposit which is gently shelving from 6.5–8m below OD represents the remains of the preinundation landscape and as such can provide information relating directly to Holocene sea-level fluctuations. If this is the case, the organic material and timber at the different depths is a resource that could yield sequential and datable palaeoenvironmental evidence of changing environments between *c* 8000 and 6000 BP.

Beyond the limit of the post-glacial deposits about 50–100m to the west, the seabed is covered with shell, gravel, and flint. Visual inspection in 9–11m of water revealed a rich source of worked material scattered over the sea floor. The large number of worked flint pieces identified in the small area subject to inspection demonstrates the archaeological wealth of a Holocene landscape that has now been lost. It also hints at the potential for archaeology in the deposit that remains.

In May 2003 further investigation of the area revealed more lithics. The flints were recorded in 7–8m of water, adjacent to the eroding peat horizon, and down slope. Monolith samples were collected from the deposits associated with the archaeology and from peat outcrops at differing depths. The depths and positions of the finds and samples are currently being calibrated.

Interpreting the archaeological and sedimentary archive

Detailed palaeoenvironmental interrogation of the submerged and stratified peat and mineral Holocene sediments collected in monolith tins will be based on palynological, diatom, foraminifera, plant macrofossil, insect, and fish and animal bone analysis. The objective is to give a high-resolution data set providing evidence of geomorphological and environmental responses to the Flandrian transgression and climate change of the early to mid-Holocene. It will help develop a chronological framework utilising radiocarbon and biostratigraphical analysis upon which to date the changes in the western Solent and the associated palaeo-system. The investigation of specific archaeological sites within this context will provide unique information about the habitat associated with occupation.

Examination of the rich archive enables us to address the following questions:

1 What can analysis of the environmental deposits tell us about the palaeo-landscape in the Solent region?
2 Can we resolve relative archaeological potential from characteristics within the environmental deposits?
3 Can the results provide a temporal context for ongoing formation processes in the western Solent?
4 What can interpretation of the submerged environmental deposits tell us about the geomorphological evolution of the Solent and the responses of the coastline to sea-level fluctuations over the last 8000 years?
5 Can this information be utilised to help model occupation patterns?
6 Can the relationship of the archaeological material to the basal landscape be resolved by detailed survey and recording?

Answers to these questions will help to gain an insight into the landscape prior to inundation and aid our understanding of the nature, scale, and pace of the system's evolution. Archaeological interpretation would help identify areas suitable for past human occupation. If areas are identified as more suitable for occupation, they can be targeted in an attempt to quantify the archaeological value of the material and, by inference, comparable inundated deposits in other near shore waters.

Defining the value of submerged landscapes — a way forward for management and research

A chronology of past events is crucial to our understanding of the region's inundation during the Flandrian transgression. In the western Solent, investigation of deposits laid down in the Holocene has the potential to provide a better understanding of the time-scale in which it was formed. The production of data for the palaeoenvironmental evolution of the Solent system in the early to mid-Holocene will provide insights into the characteristics of archaeological sites occupied prior to inundation. Detailed investigation around archaeological sites is providing a picture of occupation within the changing environment, while enabling judgements to be made about their value. This in turn will aid the management of the coastal and palaeoenvironment resource below the low water mark. An essential starting point for planning the management is the recognition that known submerged archaeological sites are eroding and are time-limited.

The Upper Palaeolithic and Mesolithic are periods which pose many questions. Relatively little is known about a way of life that lasted thousands of years in an ever-changing landscape. Each new major discovery on land brings evidence that lends itself to renewed hypotheses about lifestyles, social interaction, or exploitation of the environment. It should not be forgotten that much of the more productive land from this period is now underwater. Combining an interpretation of the coastal geomorphological evolution during the Holocene with evidence of human occupation from known sites may help locate more. It is only with sufficient archaeological material from these sites that we may be able to address some of the shortfalls in our knowledge base.

5 The North Sea project: the first palaeontological, palynological, and archaeological results

by Jan Glimmerveen, Dick Mol, Klaas Post, Jelle W F Reumer, Hans van der Plicht, John de Vos, Bas van Geel, Guido van Reenen, and Jan Peter Pals

Introduction

The southern part of the North Sea is renowned for its abundance of fossilised remains of Pleistocene mammals. These mammals inhabited the area during limited periods of the entire Pleistocene, but fossils dating from the late Pleistocene in particular are salvaged by the tens of thousands every year. In the North Sea project interdisciplinary cooperation enables accurate dating, identification, and study of this fossil fauna.

As part of this project last year an interdisciplinary investigation started with specific attention to the Eurogeul. The extraordinary circumstances of the Eurogeul locality — the floor is rich in fossil material from terrestrial and marine mammals in an excellent state of preservation — make this location pre-eminently suitable for achieving the goal of the project for this part of the North Sea. Since the Eurogeul is part of the Southern Bight of the North Sea the results of the investigations have to be presented in relation to what is already known and to the new data from the North Sea.

In this article the first results of the North Sea project will be presented. The provisional conclusions provide a few unexpected and rather surprising perspectives. Moreover, the North Sea Project and its first results show it is necessary to work in an interdisciplinary way and especially to integrate palaeontological and archaeological offshore investigations if we want to understand human evolution in Europe. The palaeontological record should therefore be regarded as an integral part of our cultural heritage.

Collection and investigation in the past

Hundreds of thousands of fossil bones of Pleistocene mammals, both terrestrial and marine, have been fished from the bottom of the North Sea between Great Britain and the Netherlands. Most of this material, first brought ashore as a bycatch as early as 1874, is without any exact locational data. Huge quantities of this material have been assembled in public and private collections. The collections in the National Museum of Natural History (Naturalis, Leiden) are considered the largest. Today some 7500 specimens of woolly mammoth *Mammuthus primigenius* are to be found in this museum, not to speak of other taxa. The commonest 'locality' name on the labels is 'Bruine Bank', or 'Brown Bank', a shallow region where many fishing vessels are actively catching flatfish such as sole, dab, turbot, or plaice. Marine mammalian remains have been considered of interglacial origin when sea level was high, whereas the fossil bones of terrestrial mammals are considered of glacial periods with a low sea level when Britain and the Low Countries were connected by what is now the Southern Bight of the North Sea. Based on the morphology in combination with the state of fossilisation the mammal bones have been placed in the early, middle and late Pleistocene.

Recent investigations in the North Sea

The North Sea Project

About a year ago the North Sea Project was started in the Netherlands. This long-term project, initiated by Naturalis (Leiden), the Natural History Museum Rotterdam, and CERPOLEX/Mammuthus, has involved the participation of a number of universities and governmental institutes, establishing a frequent and close cooperation. The broad interdisciplinary approach combines palaeontology, geology, palynology, dendrology, archaeology, and isotope science.

The project's ambitious goal is to constitute a reliable empirical basis, among other things following the identification and dating of accumulated fossil materials, in order to offer an accurate description of the biotic history of the Pleistocene in what is now the Southern Bight of the North Sea situated between the British Isles and the Netherlands.

As people were part of these biotopes the project's goal applies to them too. The questions posed are, for example, when did people enter the North Sea Basin, during which periods did they live there and in what environment?

Intensified cooperation

Intensive cooperation between collectors and the fishing industry during the last decade brought many (ie several tens of thousands) mammal fossils ashore which became available for scientific research. Fishing crew members are not only willing to cede the material for research purposes, but they also provide us with GPS coordinates for the exact localities where the material was retrieved (Mol *et al* 2003). In this way a profusion of data has been assembled which provides us with a reasonable knowledge about the places where early, middle or late Pleistocene fauna is found. Geological data from the Southern Bight, at the Netherlands Institute of Applied Geoscience (TNO-NITG), and the Geological Survey of Britain, allowed confirmation of the identifications of material as either from the early, middle or late Pleistocene. These data have formed the basis of the North Sea project.

Brown Bank locality and other Southern Bight locations

One of the richest localities of the Southern Bight of the North Sea, the Brown Bank, provided a lot of fossil material of the late Pleistocene fauna. So far, only a few radiocarbon dates of late Pleistocene mammals have been published. A series of new, unpublished radiocarbon dates are shown in Table 5.1.

Another series of new, unpublished radiocarbon dates of the late Pleistocene *Rangifer tarandus* from the Brown Bank locality and some other

Table 5.1 Radiocarbon dates (Brown Bank)

Mammuthus primigenius, woolly mammoth, metacarpal IV dext.	Tucson Az. 17634[1] Fieldnumber Dale Guthrie 412°	33,800 ± 1200 BP
Mammuthus primigenius, woolly mammoth, M3 inf. dext.	Tucson Az. 17645[1] Fieldnumber Dale Guthrie 423°	35,200 ± 2000 BP
Mammuthus primigenius, woolly mammoth, M3 inf. dext.	Tucson Az. 17643[1] Fieldnumber Dale Guthrie 421°	>36,200 BP
Mammuthus primigenius, woolly mammoth, M3 sup. sin.	Tucson Az. 17647[1] Fieldnumber Dale Guthrie 425°	36,800 ± 2400 BP
Mammuthus primigenius, woolly mammoth, M3 sup. dext.	Tucson Az. 17642[1] Fieldnumber Dale Guthrie 420°	37,900 ± 2800 BP
Mammuthus primigenius, woolly mammoth, atlas	Tucson Az. 17637[1] Fieldnumber Dale Guthrie 415°	39,800 ± 3400 BP
Mammuthus primigenius, woolly mammoth, M3 sup. dext.	Tucson Az. 17648[1] Fieldnumber Dale Guthrie 426°	>38,600 BP
Mammuthus primigenius, woolly mammoth, lunatum dext.	Tucson Az. 17638[1] Fieldnumber Dale Guthrie 416°	>38,900 BP
Mammuthus primigenius, woolly mammoth, fibula dext.	Tucson Az. 17636[1] Fieldnumber Dale Guthrie 414°	>39,000 BP
Mammuthus primigenius, woolly mammoth, triquetrum dext.	Tucson Az. 17639[1] Fieldnumber Dale Guthrie 417°	>39,300 BP
Mammuthus primigenius, woolly mammoth, axis	Tucson Az. 17635[1] Fieldnumber Dale Guthrie 413°	>40,000 BP
Mammuthus primigenius, woolly mammoth, M3 sup. dext.	Tucson Az. 17640[1] Fieldnumber Dale Guthrie 418°	>41,100 BP
Mammuthus primigenius, woolly mammoth, axis	GrA 11640*	>45,000 BP
Crocuta crocuta, hyena, ulna	GrA 11643*	40,660 ± 350-300 BP
Ovibos moschatus, musk-ox, metacarpal	GrA 11641*	36,740 ± 230 BP
Ovibos moschatus, musk-ox, metacarpal	OxA 6307[2]	35,600 ± 1200 BP
Megaloceros giganteus, giant deer, metacarpal	OxA 6308[2]	36,300 ± 1100 BP

[1] Tucson, Arizona AMS radiocarbon dating
° With acknowledgement to Dr R Dale Guthrie, Fairbanks, Alaska
* Groningen AMS radiocarbon dating
[2] Oxford University, Research Laboratory for Archaeology and the History of Art AMS radiocarbon dating

Table 5.2 Reindeer radiocarbon dates

Sample name	Laboratory number*	^{14}C age (BP) sigma		Geographical coordinates
GL02, Calcaneum	20254	44,100	+1250, −1100	52°44′ N, 03°11′ E
GL03, Metacarpal	20255	39,150	+700, −650	52°22′ N, 03°06′ E
GL05, Last Phalanx	20257	39,200	+700, −650	52°11′ N, 02°48′ E
GL06, Astragal	20294	29,460	± 250	52°11′ N, 02°48′ E
GL07, Astragal	20259	42,300	+1000, −900	52°29′ N, 03°07′ E
GL08, Radius	20260	41,200	+900, 800	52°48′ N, 02°46′ E
GL09, Epistropheus	20261	39,000	+700, −600	53°06′ N, 02°40′ E
GL14, Metacarpal	20303	>45,000		SW of the Brown Bank
GL15, Bone	20475	>45,000		SW of the Brown Bank

* GrA – Groningen AMS

locations of the Southern Bight of the North Sea are shown in Table 5.2. (First presented at the Third International Mammoth Conference, Dawson City and Whitehorse, Yukon, 24–29 May 2003.).

Finally, worth mentioning is a spectacular recent find of a mandible of the late Pleistocene sabre-toothed cat *Homotherium latidens*, described by Reumer *et al* (2003) (Fig 5.1), found on the floor of the Southern Bight of the North Sea and radiocarbon dated. The radiocarbon date made clear that *Homotherium* was part of the north-west European mammoth fauna (the late Pleistocene ecosystem) by *c* 28,000 BP.

All these radiocarbon dates suggest that the late Pleistocene 'Mammoth Fauna' with *Mammuthus primigenius, Homotherium latidens, Megaloceros giganteus, Ovibos moschatus, Rangifer tarandu-s*and *Crocuta crocuta* occupied the (Brown Bank area in the) Southern Bight of the North Sea from 44,100 to 28,000 BP.

Another provisional conclusion or hypothesis, and a very interesting aspect of further investigation, can be inferred from the list with reindeer radiocarbon dates. Reindeer inhabited the area at least in the late Pleistocene, but not continuously (note the same sort of conclusion for the late Quaternary mammalian megafauna of the Taimyr Peninsula in MacPhee *et al* 2002). *Rangifer tarandus* probably wandered in during three periods of favourable climate. Further investigation is needed to establish whether this provisional conclusion applies to the mammoth fauna as a whole. Other interesting research topics would be which animals left the area temporarily: when, why and to what refuges.

Some five nautical miles west of the Rotterdam harbour mouth, close to the buoy 'Maas Centre' and on the bottom of the Eurogeul (the dredged shipping lane), we find a concentration of mammoth bones (Fig 5.2). These mammalian remains are perfectly preserved and often show intricate anatomical detail. Sometimes bones belong to the same individual, for example, a mammoth skull with accompanying mandible. In the Eurogeul complete skeletons or parts of skeletons are found, which indicates a lack of secondary transportation (Fig 5.3). The mammoth skeletons belong to animals of all ontogenetic ages, foetus to senile. Silting up of the Eurogeul is being prevented by sand-removing suction-dredgers in order to facilitate the entry of heavy-draught ships into the port

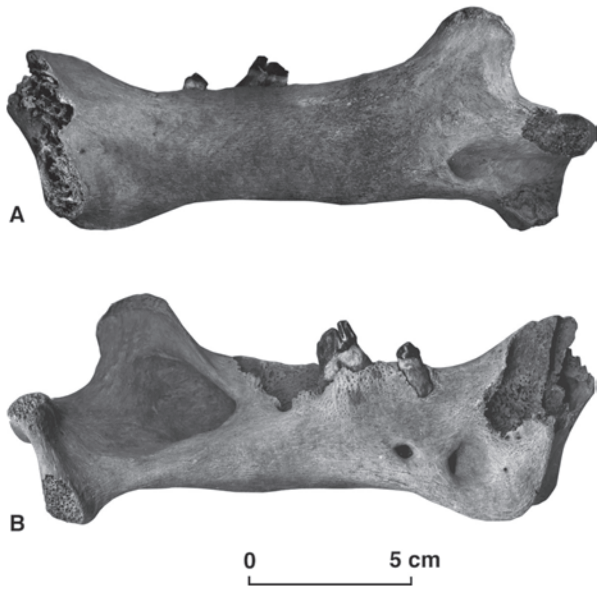


Figure 5.1 Homotherium latidens*, sabre-toothed cat. Partial mandible with well-preserved right dentary p3 and p4; the i1–i3 and m1 are missing. Trawled by the fishing vessel UK 33 from a locality south-east of the Brown Bank in the North Sea, dated* c *28,000 BP. (Collection: Natural History Museum, Rotterdam, 02–011. After Reumer* et al *2003. Photo: Natural History Museum, Rotterdam)*

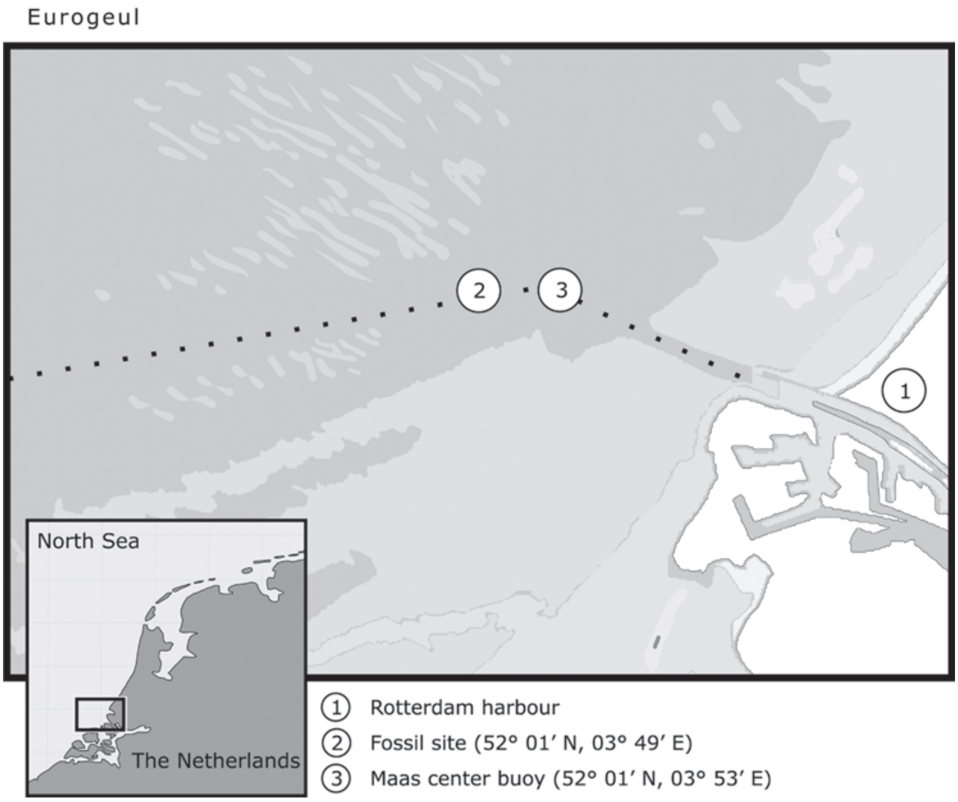


Figure 5.2 The 'Eurogeul' locality

of Rotterdam. Larger fossils, especially those of *Mammuthus,* are being freed from the sediment and stay behind on the bottom of the Eurogeul. Subsequently, smaller fishing vessels (so-called Euro-cutters) get these bones in their dredge-nets

Figure 5.3 Large cranium (right) of an old male individual of the woolly mammoth, Mammuthus primigenius*, trawled from the Eurogeul locality by the fishing vessel GO 3. When caught by the net of the GO 3 the right tusk with a length of 3.2m was still in anatomical order with the skull. Displayed together with a much smaller cranium (left) of a female woolly mammoth (from the locality Gewande, province of Noord–Brabant, the Netherlands) in the "Oertijdmuseum de Groene Poort" Boxtel, the Netherlands. (Collection: Klaas Post, Urk. Photo: Clemens Le Blanc)*

while fishing (Fig 5.4). The locality where this takes place is at 52° 01′ N, 03° 49′ E, at a depth of *c* 28m below the surface. The geology at the locality is rather complicated and subject to further study. Presently available knowledge shows the following layers from the top (= the bottom of the sea) downward:

1 The middle Holocene to recent Blight Bank Member of the Southern Bight Formation
2 Early Holocene lagoonal sediments
3 A late Weichselian/early Holocene grey clay of the Naaldwijk Formation
4 The fossiliferous Kreftenheye Formation
5 Late Saalian fluviatile deposits (that are not being touched in the Eurogeul) of the Urk Formation

The Kreftenheye Formation (4) in which the Eurogeul mammals of Pleistocene age are found can be divided into three layers: on top fine-grained fluviatile sands, underlain by fluviatile sands without marine indicators, and, finally, sands containing Eemian marine molluscs. The age of this formation is Eemian to late Weichselian (Laban *et al* 1984; Laban and Rijsdijk 2002).

Faunal list

CERPOLEX/Mammuthus, in close collaboration with the Natural History Museum, Rotterdam and the National Museum of Natural History in Leiden, led several one-day expeditions to the area

Figure 5.4 Participants of the first CERPOLEX/Mammuthus expedition (2001) on the Eurogeul, North Sea, showing freshly dredged remains of the woolly mammoth (left) and the woolly rhinoceros (right). (Photo: CERPOLEX/Francis Latreille)

(Fig 5.5). Together with the material that has been brought ashore by the Euro-cutters we now have the following fauna from the Eurogeul locality:

Proboscidea
- *Mammuthus primigenius* – woolly mammoth

Artiodactyla
- *Bison priscus* – bison
- *Rangifer tarandus* – reindeer
- *Megaloceros giganteus* – Irish elk
- *Alces alces* – moose
- *Cervus elaphus* – red deer

Perissodactyla
- *Equus caballus* – horse
- *Coelodonta antiquitatis* – woolly rhino

Carnivora – Fissipedia
- *Ursus arctos* – brown bear
- *Crocuta crocuta* – hyaena
- *Panthera spelaea* – cave lion
- *Canis lupus* – wolf

Figure 5.5 Hundreds of remains of the late Pleistocene mammoth fauna have been trawled from the seabed of the Eurogeul during the first CERPOLEX/Mammuthus expedition, 2001, by the fishing vessel GO 33. Photo: CERPOLEX/Francis Latreille

Carnivora – Pinnipedia

Phocidae
- *Pagophilus groenlandica* – harp seal
- *Pusa hispida* – ringed seal

Odobenidae
- *Odobenus rosmarus* – walrus

Cetacea – Odontoceti

Monodontidae
- *Delphinapterus leucas* – beluga

Delphinidae
- *Orcinus orca* – killer whale

Cetacea – Mysticeti

Eschrichtidae
- *Eschrichtius robustus* – grey whale

Radiocarbon dating

Samples for radiocarbon dating purposes were taken from all terrestrial and marine species found in the Eurogeul locality. Eleven results are so far known (Tables 5.2 and 5.3). Other measurements are now being processed at the Centre for Isotope Research, Radiocarbon Laboratory, University of Groningen (the Netherlands).

Terrestrial mammals

With the exception of *Cervus elaphus* and *Alces alces*, the fauna presented in the faunal list can be considered as typical mammoth fauna as found in many places in Eurasia. Three antler fragments of *C. elaphus* clearly show traces of human activity and they are probably, in one case with certainty, of early Holocene date.

Coelodonta antiquitatis was an extremely common element during the late Pleistocene in the southern part of the North Sea and is also common in the Eurogeul fauna. There may be no other region in Eurasia where this species is found in such abundance. This fact must be due to biotope characteristics and/or to biogeographical phenomena. Woolly rhino had a wide distribution, from Britain in the west to north-east Siberia in the east. It is however completely absent from North America (Boeskorov 2001), indicating it did not cross the Bering land bridge.

Flerov (1967) suggested that leaves and twigs of shrubs must have been the major food source for the woolly rhino. The absence of shrubs in the late Pleistocene mammoth steppe of north-east Siberia would then have been sufficient reason why this species never reached North America, explaining its absence from the New World. However, food remains found in dental crevices and in the intestinal tract (eg in the Churapachi rhino from Yakutia; Lazarev 1977) showed that tough grasses were the major food source. Currently (Ermolova 1978; Boeskorov 2001) it is supposed that large parts of the extreme north-east were covered with hard layers of frozen snow during the late Pleistocene, hampering the spread of

Table 5.3 Terrestrial mammals (Eurogeul)

Species and skeletal part	Laboratory number	Results
Cervus elaphus, red deer, modified antler	GrA 22999*	8070 ± 50 BP
Alces alces, moose, antler	GrA 23201*	7970 ± 60 BP
Mammuthus primigenius, woolly mammoth, fragment cranium	GrN 27410[n]	37,580 −740/+810 BP
Coelodonta antiquitatis, fragment pelvic	GrN 27411[n]	39,910 −950/+1070 BP
Panthera leo spelaea, lion, ulna	GrA 23151*	42,230 −530,+570 BP
Equus cf caballus, ulna	GrA 22585*	43,550 −1050/+1200 BP
Mammuthus primigenius, woolly mammoth, fibula juvenile individual	GrA 20134*	43,800 −550/+600 BP
Canis lupus, wolf, left femur	GrA 22183*	48,400 −3300/+5800 BP

* Groningen AMS radiocarbon dating
[n] Groningen Conventional radiocarbon dating

woolly rhino to North America. It is also noteworthy that *Coelodonta antiquitatis* is absent from the mammoth fauna on the entire Taymir Peninsula.

Marine mammals

Marine taxa from the Pleistocene have been found in the southern part of the North Sea and the Eurogeul. Based on the morphology in combination with the state of fossilisation and the radiocarbon dates we may conclude that the fossils from the Eurogeul locality belong to a cold late Pleistocene fauna with harp seal *Pagophilus groenlandica*, ringed seal *Pusa hispida*, walrus *Odobenus rosmarus*, beluga *Delphinapterus leucas*, orca (killer whale) *Orcinus orca*, and grey whale *Eschrichtius robustus*.

For fossil walrus the North Sea is probably the richest source in the world. Thousands of skeletal parts and hundreds of (sometimes complete) skulls were found. Datings lie between >48,500 and 23,500 BP (Aaris-Sørensen *et al* 1990; Post 1999) indicating that walrus occurred for a long period of time (albeit perhaps intermittently). This rather southern occurrence of walrus has a parallel in the Pacific Ocean (Hoshimi and Akagi 1994). Evidently the species had a more southern distribution during the coldest phase of the last Ice Age, both in the Atlantic and Pacific Oceans.

Pleistocene occurrence of beluga and harp seal is clearly evidenced by North Sea fossils (Post and Kompanje 1995; Post 1999). Two datings of beluga (from the coast of Zeeland and the Brown Bank) resulted in 38,500 ± 800 BP (UtC 3752) and 34,600 −400/+500 BP (UtC 3753) respectively (Post 1999). Harp seal must have also occurred in vast colonies along the (Dutch) coast, but unfortunately only one fossil from the Brown Bank has been dated thus far (45,000 ± 1,500 BP (UtC 7883) Post 1999).

The coasts of the present North Sea have yielded many fossils of grey whale and proved the early Holocene Atlantic presence of this extant Pacific whale (Bryant 1995; van Deinse and Junge 1937). Fossils from the Eurogeul also confirm with certainty the late Pleistocene occurrence of this species in the Atlantic Ocean.

All species found are either bound to coastal environments (the pinnipeds), or are species that can thrive in very shallow water (beluga, grey whale, killer whale).

Molluscs

The following species of fossil molluscs were collected during the various Eurogeul expeditions:

Natica catena (Da Costa 1778)
Buccinum undatum (Linnaeus 1758)

Table 5.4 Marine mammals (Eurogeul)

Species and skeletal part	Laboratory number	Results
Eschrichtius robustus, grey whale, vertebra	GrA 22182*	>45,400 BP
Delphinapterus leucas, beluga, axis	GrA 22179*	>47,500 BP
Odobenus rosmarus, walrus, cranium fragment	GrA 22178*	>48,500 BP

* Groningen AMS radiocarbon dating

Nassarius reticulatus (Linnaeus 1758)
Mytilus edulis (Linnaeus 1758)
Chlamys varia (Linnaeus 1758)
Ostrea edulis (Linnaeus 1758)
Acanthocardia tuberculata (Linnaeus 1758)
Cerastoderma edule edule (Linnaeus 1758)
Cerastoderma edule major (Bucqoy, Dautzenberg, and Dollfuss 1895)
Cerastoderma glaucum (Poiret 1789)
Laevicardium crassum (Gmelin 1791)
Mactra corallina plistoneerlandica (van Regteren Altena 1937)
Mactra glauca (Born 1778)
Spisula elliptica (Brown 1827)
Spisula solida (Linnaeus 1758)
Lutraria lutraria (Linnaeus 1758)
Macoma balthica (Linnaeus 1758)
Venerupis aurea senescens (Cocconi 1873)
Mya truncata (Linnaeus 1758)
Zirfaea crispata (Linnaeus 1758)

The provisional malacological investigations on the Eurogeul molluscs have discovered that these molluscs are also known from the Maasvlakte, an artificial island off the coast of the province of South Holland which is partially built of sediments from the Eurogeul. A number of species from this fauna are very distinct, but we remain uncertain about their stratigraphic origin due to the lack of hard radiometric dates. Some 'warm' indicators, such as *Acanthocardia tuberculata, Mactra glauca*, and *Mimachlamys varia*, have previously been attributed to an Eemian age. However, the lack or scarcity of other typical 'warm' Eemian indicators, such as *Lucinella divaricata, Timoclea ovata*, and *Bittium reticulatum*, may indicate suboptimal climatic conditions, either from the beginning or (preferably) from the later Eemian/early Weichselian stages. The very large *Cerastoderma edule* forma *major* may also be attributed to this suboptimal climatic stage. Finally, the stratigraphic origin of the boreal-arctic *Astarte borealis*, common on the Maasvlakte, but not found during the Eurogeul expeditions, remains enigmatic. A cooccurrence with the cool *c* 50,000-year-old marine mammals reported herein cannot be ruled out. However, we tend to believe that the latter species might also represent an older cold stage.

Palynological dating of sediments and palaeoenvironmental reconstructions

Within the framework of the multidisciplinary Eurogeul investigations large pieces of sediment were recovered from the bottom of the Eurogeul area together with the bones. Subsamples of *c* 100×100×100mm were cut from 50 different pieces. Contamination was avoided by cutting undisturbed material from inside large pieces. Pollen samples were prepared of all the subsamples and their contents were screened in order to be able to date the sediments by using the palynological record from the Netherlands, and to get an impression of the existing environments. The pollen spectra were compared with Weichselian and Holocene radiocarbon-dated pollen records (Ran 1990; van Geel *et al* 1981, 1989). Two periods appeared to be represented in the sediments. Some of the samples showed the palynological characteristics of Weichselian interstadials and other samples appeared to be of Boreal age. The microfossil and macrofossil records of two examples (NRZ-1 and NRZ-2) are shown in Tables 5.5 (microfossils) and 5.6 (macrofossils) and discussed below.

Sample NRZ-1 consists of peat, mainly formed by mosses of the Amblystegiaceae. The pollen spectrum is dominated by Cyperaceae. The presence of some lumps of pollen of Cyperaceae, in combination with hyphopodia of *Gaeumannomyces* (parasitic fungus on *Carex* species; Pals *et al* 1980; van Geel *et al* 1989) points to a local occurrence of Cyperaceae. The macrofossil record shows that a species of *Carex* sect. *Acutae* was growing at the sampling site. Combined with the abundance of the mosses *Calliergonella cuspidata*, *Scorpidium scorpidioides*, *S. revolvens* and *Drepanocladus* sp this indicates an association of the Parvocaricetea. This vegetation class presently occurs in large areas of North America, north and east Europe, and Siberia (Schaminée *et al* 1995). *Scorpidium scorpidioides* is known to be abundant in consistently wet spots of particularly minerotrophic fens and the presence of *Scorpidium revolvens* indicates a quaking fen-like vegetation. Also the algae *Pediastrum*, *Botryococcus* and *Spirogyra*, combined with Types 128A and 128B (probably algal spores; van Geel *et al* 1989) point to stagnant shallow fresh water.

The extremely low amount of tree pollen reflects a treeless landscape. The number of pollen of 'dry' herbaceous taxa is very limited and their representation indicates a low diversity of the vegetation. Comparison with the detailed palynological studies by Ran (1990) point to Weichselian interstadial conditions and an age preceding the Upper Pleniglacial of the Weichselian (during which polar desert conditions prevailed), which means that sample NRZ-1 is older than *c* 26,000 BP and probably younger than *c* 50,000 BP.

Sample NRZ-2 consists of peaty clay. Arboreal taxa (mainly *Corylus*, *Pinus*, and *Quercus*) dominate the pollen spectrum. The representation of *Tilia* and *Ulmus* indicates that these trees had already migrated to the region. Comparison with a complete record of the early Holocene vegetation history in the Netherlands (van Geel *et al* 1981) points to a Boreal age (dominance of *Corylus* and absence of *Alnus*; period between *c* 9150 and *c* 7900 BP). Charred particles of botanical origin are present in the pollen slides and in the macrofossil samples. Some of the charred

Table 5.5 Percentages of macrofossils in two sediment samples from the Eurogeul

Taxa/samples	NRZ-1	NRZ-2
**Alnus*	–	0.8
**Betula*	–	3.0
**Corylus*	–	38.8
**Pinus*	0.5	24.2
**Picea*	0.5	0.4
**Quercus*	–	10.4
**Salix*	1.0	1.9
**Tilia*	–	1.5
**Ulmus*	–	3.0
*Apiaceae	–	1.5
**Artemisia*	+	–
*Cyperaceae	90.1	7.3
*Ericales	0.5	–
Fabaceae	+	–
**Humulus*	–	0.4
Iris pseudacorus	–	0.4
*Poaceae	5.4	6.5
charred cuticles Poaceae	–	+
Potentilla type	+	–
*Ranunculaceae	–	0.4
Scabiosa	+	–
Sparganium	–	5.4
**Thalictrum*	1.0	–
Typha angustifolia	–	0.8
Monolete verrucate fern spores	0.5	1.8
Monolete psilate fern spores	–	0.8
Equisetum	–	238.2
Pediastrum	10.3	0.4
Botryococcus	3.2	–
Mougeotia laetevirens type	–	0.4
Spirogyra	1.6	0.4
Type 128A	6.5	2.7
Type 128B	0.5	0.8
Rivularia type	–	0.4
Gaeumannomyces, hyphopodia	2.2	–
Ustulina deusta, ascospores	–	0.8
charred particles	–	++

Taxa included in the pollen sum (base of percentage calculations) have been marked with an asterix.

microfossils were recognisable as cuticles of grasses (Poaceae). Mesolithic people may have been responsible for fires while creating open hunting areas, but we cannot exclude the possibility of natural fires. Local taxa indicate shallow fresh water which was in a phase of terrestrialisation, considering the dominance of *Equisetum* (spores and vegetative remains) together with *Alisma plantago-aquatica*, *Eupatorium cannabinum*, *Iris pseudacorus*, *Mentha aquatica*, *Phragmites australis*, *Sparganium*, *Bythinia*, *Cladocera*, fresh water sponges, and algae (*Spirogyra*, *Mougeotia*).

Evidence of Holocene human occupation of the Eurogeul locality

The surroundings of the present day Eurogeul, as part of the southern North Sea, were inhabited by terrestrial and marine mammals during the late Pleistocene, and terrestrial mammals during the early Holocene. Moreover, during this period there is conclusive evidence of the presence of humans in this area.

Sophisticatedly carved tools made from red deer antler and auroch bone (metapodals) (see for example Louwe Kooijmans 1970–71), definitely Mesolithic material, have been salvaged from the bottom of the southern North Sea. Many other finds imply that Mesolithic people hunted moose, horse, and wild boar as well in this area. Recent finds which have been radiocarbon-dated confirm this hypothesis (Post 2000; Glimmerveen *et al* 2003) (see Table 5.7 for radiocarbon dating on wild boar). In addition, radiocarbon dating of two recently found samples of red deer phalanxes confirms that this animal inhabited the North Sea Basin during the same period as Mesolithic people did (see Table 5.7 below).

Recently three artefacts made of red deer antler have been fished from the bottom of the Eurogeul. Since these artefacts are fresh and bear no marks at all of secondary transportation, we may conclude that the artefacts were found more or less *in situ*. Radiocarbon dating of one of these artefacts (the first dating in Table 5.3) constitutes further proof for the coexistence of Mesolithic people and red deer in the southern North Sea and in the area of the Eurogeul in particular. This modified antler of the Mesolithic period can be placed in the Boreal (*c* 9150–7900 BP). All three artefacts, which are quite similar, match other artefacts of red deer antler found elsewhere on the bottom of the southern North Sea and with finds on both sides of the North Sea in Great Britain and on the continent especially in the Netherlands (see for example Louwe Kooijmans 2001). Mesolithic people often used antler as raw material for their tools and they almost exclusively used antler from red deer.

Table 5.6 Macrofossils (presence/absence) in two sediment samples from the Eurogeul

Taxa/samples	NRZ-1	NRZ-2
Alisma plantago-aquatica, fruits	–	+
Carex pseudocyperus, perigynium	–	+
Carex rostrata / vesicaria, achenes	–	+
Carex vesicaria, perigynia	–	+
Carex sect. *Acutae*, achenes	+	–
Eupatorium cannabinum, fruit	–	+
Mentha aquatica, achenes	–	+
Myrica gale, fruit	–	+
Phragmites australis, seeds	–	+
Ranunculus flammula, achenes	–	+
Typha, seeds	–	+
Equisetum, vegetative remains	–	+
Calliergonella cuspidata, leaves	++	–
Scorpidium scorpidioides, leaves	++	–
Scorpidium revolvens, leaves	+	–
Drepanocladus sp., leaves	+	–
Acari	+	–
Bryozoa, statoblasts	–	+
Bythinia, opercula	–	+
Cladocera, ephippia	–	+
fresh water sponges, gemmules	–	+

The findings and the palynological data prove that Mesolithic people lived and, probably, hunted in various ways in the surroundings of the present day Eurogeul as a part of the forested environments the southern North Sea Basin which formed the habitat of red deer, *Cervus elaphus*, and wild boar, *Sus scrofa*.

Discussion and conclusion

Based on data of beluga and walrus fossils from the North Sea floor and recent radiocarbon dates on North Sea specimen of the mammoth fauna we may deduce that marine as well as terrestrial mammals, albeit with intervals, were present in

Table 5.7 Results of ^{14}C dating of North Sea red deer, wild boar, and *Homo*

Sample name	Laboratory number*	^{14}C age (BP)	sigma	Geographical coordinates
Cervus elaphus				
GL01, Second Phalanx	GrA 20353	8350	50	52°27′ N, 02°55′ E
GL04, First Phalanx	GrA 20256	8820	60	52°22′ N, 03°06′ E
Sus scrofa				
No.2684, Humerus	UtC 7886	9450	70	Southern Bight North Sea
Homo sapiens				
Mandibula	GrA 23205	9870	70	Southern Bight North Sea
No.1063, Cranial bone	UtC 3750	9640	400	52°10′ N, 02°49′ E
Cranial bone	?	8340	130	Southern Bight North Sea
Mandibula	GrA 11642	8370	50	53°00′ N, 02°54′ E

* GrA – Groningen AMS; UtC – Utrecht AMS

what is now the Southern Bight of the North Sea between the British Isles and the Netherlands from 44,100 to 28,000 BP. Therefore we must conclude that, at least for a part (or parts) of this period, marine and terrestrial mammals were contemporaneous.

Based on the first few data of terrestrial mammals of the mammoth steppe ecosystem from the Eurogeul we may conclude that events were (at least partly) parallel those in other parts of the Southern Bight of the North Sea. Palynological investigation supports this conclusion.

However, as yet we cannot draw the same conclusion for the marine mammals. Although the marine species found in the Eurogeul correspond with those from the North Sea and belong to a cold late Pleistocene fauna as well, radiocarbon datings provide no conclusive evidence. Perhaps surprisingly, provisional malacological investigations do not show marine taxa from this period either.

Although the Eurogeul investigation has only just begun to produce its first, still limited, data, we are developing a very interesting and rather spectacular hypothesis for further investigations. This hypothesis is that the site was part of the Rhine-Meuse delta system, a large estuary fading out in a shallow North Sea. Marine mammals, such as pinnipeds, beluga, and grey whale could easily enter this system and their remains must have been deposited together with carcasses of terrestrial mammals, such as the woolly mammoths and woolly rhinoceroses, which were caught for whatever reason by the river system.

The Eurogeul area was inhabited by terrestrial mammals and by people during the early Holocene, especially the Boreal, as palynological investigations, and palaeogeographical and archaeological evidence demonstrate. As yet we only have limited (though conclusive) evidence. Here too we need further investigations in order to be able to compare with continental cultures and to explore the possibility of a Palaeolithic human presence in the area and to answer the question of whether people were part of the mammoth fauna too.

The first results of the expeditions and investigations are encouraging and show the necessity and the intriguing possibilities of further multidisciplinary investigations.

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5 The North Sea project: the first palaeontological, palynological, and archaeological results

by Jan Glimmerveen, Dick Mol, Klaas Post, Jelle W F Reumer, Hans van der Plicht, John de Vos, Bas van Geel, Guido van Reenen, and Jan Peter Pals

Introduction

The southern part of the North Sea is renowned for its abundance of fossilised remains of Pleistocene mammals. These mammals inhabited the area during limited periods of the entire Pleistocene, but fossils dating from the late Pleistocene in particular are salvaged by the tens of thousands every year. In the North Sea project interdisciplinary cooperation enables accurate dating, identification, and study of this fossil fauna.

As part of this project last year an interdisciplinary investigation started with specific attention to the Eurogeul. The extraordinary circumstances of the Eurogeul locality — the floor is rich in fossil material from terrestrial and marine mammals in an excellent state of preservation — make this location pre-eminently suitable for achieving the goal of the project for this part of the North Sea. Since the Eurogeul is part of the Southern Bight of the North Sea the results of the investigations have to be presented in relation to what is already known and to the new data from the North Sea.

In this article the first results of the North Sea project will be presented. The provisional conclusions provide a few unexpected and rather surprising perspectives. Moreover, the North Sea Project and its first results show it is necessary to work in an interdisciplinary way and especially to integrate palaeontological and archaeological offshore investigations if we want to understand human evolution in Europe. The palaeontological record should therefore be regarded as an integral part of our cultural heritage.

Collection and investigation in the past

Hundreds of thousands of fossil bones of Pleistocene mammals, both terrestrial and marine, have been fished from the bottom of the North Sea between Great Britain and the Netherlands. Most of this material, first brought ashore as a bycatch as early as 1874, is without any exact locational data. Huge quantities of this material have been assembled in public and private collections. The collections in the National Museum of Natural History (Naturalis, Leiden) are considered the largest. Today some 7500 specimens of woolly mammoth *Mammuthus primigenius* are to be found in this museum, not to speak of other taxa. The commonest 'locality' name on the labels is 'Bruine Bank', or 'Brown Bank', a shallow region where many fishing vessels are actively catching flatfish such as sole, dab, turbot, or plaice. Marine mammalian remains have been considered of interglacial origin when sea level was high, whereas the fossil bones of terrestrial mammals are considered of glacial periods with a low sea level when Britain and the Low Countries were connected by what is now the Southern Bight of the North Sea. Based on the morphology in combination with the state of fossilisation the mammal bones have been placed in the early, middle and late Pleistocene.

Recent investigations in the North Sea

The North Sea Project

About a year ago the North Sea Project was started in the Netherlands. This long-term project, initiated by Naturalis (Leiden), the Natural History Museum Rotterdam, and CERPOLEX/Mammuthus, has involved the participation of a number of universities and governmental institutes, establishing a frequent and close cooperation. The broad interdisciplinary approach combines palaeontology, geology, palynology, dendrology, archaeology, and isotope science.

The project's ambitious goal is to constitute a reliable empirical basis, among other things following the identification and dating of accumulated fossil materials, in order to offer an accurate description of the biotic history of the Pleistocene in what is now the Southern Bight of the North Sea situated between the British Isles and the Netherlands.

As people were part of these biotopes the project's goal applies to them too. The questions posed are, for example, when did people enter the North Sea Basin, during which periods did they live there and in what environment?

Intensified cooperation

Intensive cooperation between collectors and the fishing industry during the last decade brought many (ie several tens of thousands) mammal fossils ashore which became available for scientific research. Fishing crew members are not only willing to cede the material for research purposes, but they also provide us with GPS coordinates for the exact localities where the material was retrieved (Mol *et al* 2003). In this way a profusion of data has been assembled which provides us with a reasonable knowledge about the places where early, middle or late Pleistocene fauna is found. Geological data from the Southern Bight, at the Netherlands Institute of Applied Geoscience (TNO-NITG), and the Geological Survey of Britain, allowed confirmation of the identifications of material as either from the early, middle or late Pleistocene. These data have formed the basis of the North Sea project.

Brown Bank locality and other Southern Bight locations

One of the richest localities of the Southern Bight of the North Sea, the Brown Bank, provided a lot of fossil material of the late Pleistocene fauna. So far, only a few radiocarbon dates of late Pleistocene mammals have been published. A series of new, unpublished radiocarbon dates are shown in Table 5.1.

Another series of new, unpublished radiocarbon dates of the late Pleistocene *Rangifer tarandus* from the Brown Bank locality and some other

Table 5.1 Radiocarbon dates (Brown Bank)

Mammuthus primigenius, woolly mammoth, metacarpal IV dext.	Tucson Az. 17634[1] Fieldnumber Dale Guthrie 412°	33,800 ± 1200 BP
Mammuthus primigenius, woolly mammoth, M3 inf. dext.	Tucson Az. 17645[1] Fieldnumber Dale Guthrie 423°	35,200 ± 2000 BP
Mammuthus primigenius, woolly mammoth, M3 inf. dext.	Tucson Az. 17643[1] Fieldnumber Dale Guthrie 421°	>36,200 BP
Mammuthus primigenius, woolly mammoth, M3 sup. sin.	Tucson Az. 17647[1] Fieldnumber Dale Guthrie 425°	36,800 ± 2400 BP
Mammuthus primigenius, woolly mammoth, M3 sup. dext.	Tucson Az. 17642[1] Fieldnumber Dale Guthrie 420°	37,900 ± 2800 BP
Mammuthus primigenius, woolly mammoth, atlas	Tucson Az. 17637[1] Fieldnumber Dale Guthrie 415°	39,800 ± 3400 BP
Mammuthus primigenius, woolly mammoth, M3 sup. dext.	Tucson Az. 17648[1] Fieldnumber Dale Guthrie 426°	>38,600 BP
Mammuthus primigenius, woolly mammoth, lunatum dext.	Tucson Az. 17638[1] Fieldnumber Dale Guthrie 416°	>38,900 BP
Mammuthus primigenius, woolly mammoth, fibula dext.	Tucson Az. 17636[1] Fieldnumber Dale Guthrie 414°	>39,000 BP
Mammuthus primigenius, woolly mammoth, triquetrum dext.	Tucson Az. 17639[1] Fieldnumber Dale Guthrie 417°	>39,300 BP
Mammuthus primigenius, woolly mammoth, axis	Tucson Az. 17635[1] Fieldnumber Dale Guthrie 413°	>40,000 BP
Mammuthus primigenius, woolly mammoth, M3 sup. dext.	Tucson Az. 17640[1] Fieldnumber Dale Guthrie 418°	>41,100 BP
Mammuthus primigenius, woolly mammoth, axis	GrA 11640*	>45,000 BP
Crocuta crocuta, hyena, ulna	GrA 11643*	40,660 ± 350-300 BP
Ovibos moschatus, musk-ox, metacarpal	GrA 11641*	36,740 ± 230 BP
Ovibos moschatus, musk-ox, metacarpal	OxA 6307[2]	35,600 ± 1200 BP
Megaloceros giganteus, giant deer, metacarpal	OxA 6308[2]	36,300 ± 1100 BP

[1] Tucson, Arizona AMS radiocarbon dating
° With acknowledgement to Dr R Dale Guthrie, Fairbanks, Alaska
* Groningen AMS radiocarbon dating
[2] Oxford University, Research Laboratory for Archaeology and the History of Art AMS radiocarbon dating

Table 5.2 Reindeer radiocarbon dates

Sample name	Laboratory number*	^{14}C age (BP) sigma		Geographical coordinates
GL02, Calcaneum	20254	44,100	+1250, −1100	52°44′ N, 03°11′ E
GL03, Metacarpal	20255	39,150	+700, −650	52°22′ N, 03°06′ E
GL05, Last Phalanx	20257	39,200	+700, −650	52°11′ N, 02°48′ E
GL06, Astragal	20294	29,460	± 250	52°11′ N, 02°48′ E
GL07, Astragal	20259	42,300	+1000, −900	52°29′ N, 03°07′ E
GL08, Radius	20260	41,200	+900, 800	52°48′ N, 02°46′ E
GL09, Epistropheus	20261	39,000	+700, −600	53°06′ N, 02°40′ E
GL14, Metacarpal	20303	>45,000		SW of the Brown Bank
GL15, Bone	20475	>45,000		SW of the Brown Bank

* GrA – Groningen AMS

locations of the Southern Bight of the North Sea are shown in Table 5.2. (First presented at the Third International Mammoth Conference, Dawson City and Whitehorse, Yukon, 24–29 May 2003.).

Finally, worth mentioning is a spectacular recent find of a mandible of the late Pleistocene sabre-toothed cat *Homotherium latidens*, described by Reumer *et al* (2003) (Fig 5.1), found on the floor of the Southern Bight of the North Sea and radiocarbon dated. The radiocarbon date made clear that *Homotherium* was part of the north-west European mammoth fauna (the late Pleistocene ecosystem) by *c* 28,000 BP.

All these radiocarbon dates suggest that the late Pleistocene 'Mammoth Fauna' with *Mammuthus primigenius, Homotherium latidens, Megaloceros giganteus, Ovibos moschatus, Rangifer tarandus*and *Crocuta crocuta* occupied the (Brown Bank area in the) Southern Bight of the North Sea from 44,100 to 28,000 BP.

Another provisional conclusion or hypothesis, and a very interesting aspect of further investigation, can be inferred from the list with reindeer radiocarbon dates. Reindeer inhabited the area at least in the late Pleistocene, but not continuously (note the same sort of conclusion for the late Quaternary mammalian megafauna of the Taimyr Peninsula in MacPhee *et al* 2002). *Rangifer tarandus* probably wandered in during three periods of favourable climate. Further investigation is needed to establish whether this provisional conclusion applies to the mammoth fauna as a whole. Other interesting research topics would be which animals left the area temporarily: when, why and to what refuges.

Some five nautical miles west of the Rotterdam harbour mouth, close to the buoy 'Maas Centre' and on the bottom of the Eurogeul (the dredged shipping lane), we find a concentration of mammoth bones (Fig 5.2). These mammalian remains are perfectly preserved and often show intricate anatomical detail. Sometimes bones belong to the same individual, for example, a mammoth skull with accompanying mandible. In the Eurogeul complete skeletons or parts of skeletons are found, which indicates a lack of secondary transportation (Fig 5.3). The mammoth skeletons belong to animals of all ontogenetic ages, foetus to senile. Silting up of the Eurogeul is being prevented by sand-removing suction-dredgers in order to facilitate the entry of heavy-draught ships into the port

Figure 5.1 Homotherium latidens*, sabre-toothed cat. Partial mandible with well-preserved right dentary p3 and p4; the i1–i3 and m1 are missing. Trawled by the fishing vessel UK 33 from a locality south-east of the Brown Bank in the North Sea, dated* c *28,000 BP. (Collection: Natural History Museum, Rotterdam, 02–011. After Reumer* et al *2003. Photo: Natural History Museum, Rotterdam)*

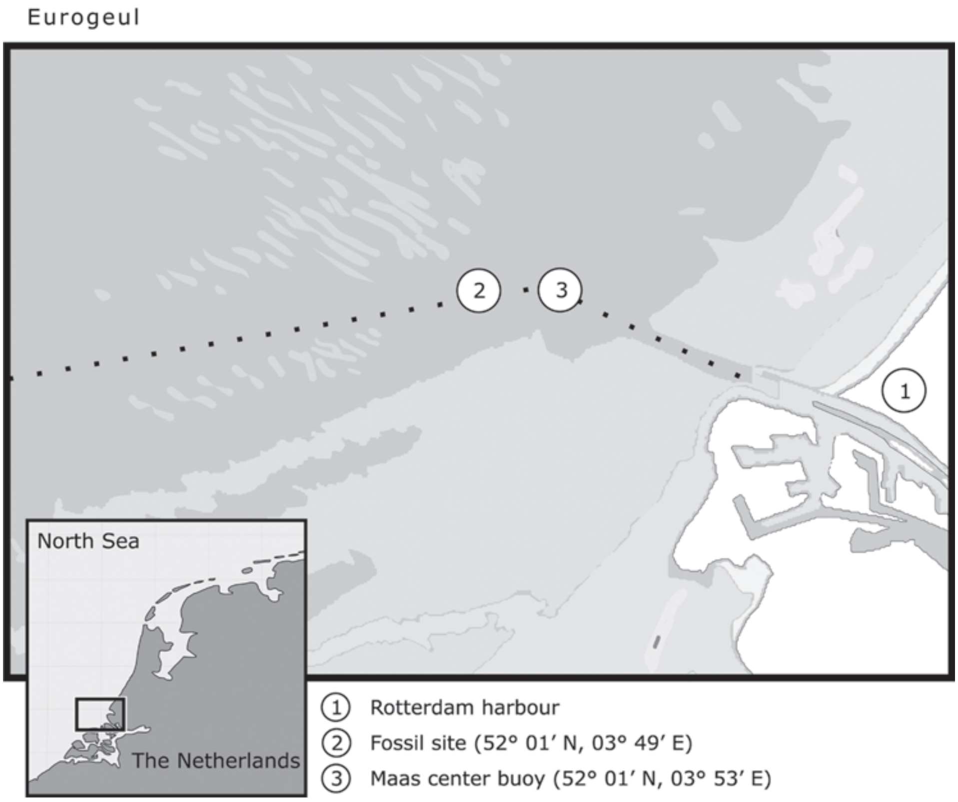

Figure 5.2 The 'Eurogeul' locality

of Rotterdam. Larger fossils, especially those of *Mammuthus,* are being freed from the sediment and stay behind on the bottom of the Eurogeul. Subsequently, smaller fishing vessels (so-called Euro-cutters) get these bones in their dredge-nets while fishing (Fig 5.4). The locality where this takes place is at 52° 01′ N, 03° 49′ E, at a depth of *c* 28m below the surface. The geology at the locality is rather complicated and subject to further study. Presently available knowledge shows the following layers from the top (= the bottom of the sea) downward:

Figure 5.3 Large cranium (right) of an old male individual of the woolly mammoth, Mammuthus primigenius*, trawled from the Eurogeul locality by the fishing vessel GO 3. When caught by the net of the GO 3 the right tusk with a length of 3.2m was still in anatomical order with the skull. Displayed together with a much smaller cranium (left) of a female woolly mammoth (from the locality Gewande, province of Noord–Brabant, the Netherlands) in the "Oertijdmuseum de Groene Poort" Boxtel, the Netherlands. (Collection: Klaas Post, Urk. Photo: Clemens Le Blanc)*

1 The middle Holocene to recent Blight Bank Member of the Southern Bight Formation
2 Early Holocene lagoonal sediments
3 A late Weichselian/early Holocene grey clay of the Naaldwijk Formation
4 The fossiliferous Kreftenheye Formation
5 Late Saalian fluviatile deposits (that are not being touched in the Eurogeul) of the Urk Formation

The Kreftenheye Formation (4) in which the Eurogeul mammals of Pleistocene age are found can be divided into three layers: on top fine-grained fluviatile sands, underlain by fluviatile sands without marine indicators, and, finally, sands containing Eemian marine molluscs. The age of this formation is Eemian to late Weichselian (Laban *et al* 1984; Laban and Rijsdijk 2002).

Faunal list

CERPOLEX/Mammuthus, in close collaboration with the Natural History Museum, Rotterdam and the National Museum of Natural History in Leiden, led several one-day expeditions to the area

Figure 5.4 Participants of the first CERPOLEX/Mammuthus expedition (2001) on the Eurogeul, North Sea, showing freshly dredged remains of the woolly mammoth (left) and the woolly rhinoceros (right). (Photo: CERPOLEX/Francis Latreille)

(Fig 5.5). Together with the material that has been brought ashore by the Euro-cutters we now have the following fauna from the Eurogeul locality:

Proboscidea
- *Mammuthus primigenius* – woolly mammoth

Artiodactyla
- *Bison priscus* – bison
- *Rangifer tarandus* – reindeer
- *Megaloceros giganteus* – Irish elk
- *Alces alces* – moose
- *Cervus elaphus* – red deer

Perissodactyla
- *Equus caballus* – horse
- *Coelodonta antiquitatis* – woolly rhino

Carnivora – Fissipedia
- *Ursus arctos* – brown bear
- *Crocuta crocuta* – hyaena
- *Panthera spelaea* – cave lion
- *Canis lupus* – wolf

Figure 5.5 Hundreds of remains of the late Pleistocene mammoth fauna have been trawled from the seabed of the Eurogeul during the first CERPOLEX/Mammuthus expedition, 2001, by the fishing vessel GO 33. Photo: CERPOLEX/Francis Latreille

Carnivora – Pinnipedia

Phocidae
- *Pagophilus groenlandica* – harp seal
- *Pusa hispida* – ringed seal

Odobenidae
- *Odobenus rosmarus* – walrus

Cetacea – Odontoceti

Monodontidae
- *Delphinapterus leucas* – beluga

Delphinidae
- *Orcinus orca* – killer whale

Cetacea – Mysticeti

Eschrichtidae
- *Eschrichtius robustus* – grey whale

Radiocarbon dating

Samples for radiocarbon dating purposes were taken from all terrestrial and marine species found in the Eurogeul locality. Eleven results are so far known (Tables 5.2 and 5.3). Other measurements are now being processed at the Centre for Isotope Research, Radiocarbon Laboratory, University of Groningen (the Netherlands).

Terrestrial mammals

With the exception of *Cervus elaphus* and *Alces alces*, the fauna presented in the faunal list can be considered as typical mammoth fauna as found in many places in Eurasia. Three antler fragments of *C. elaphus* clearly show traces of human activity and they are probably, in one case with certainty, of early Holocene date.

Coelodonta antiquitatis was an extremely common element during the late Pleistocene in the southern part of the North Sea and is also common in the Eurogeul fauna. There may be no other region in Eurasia where this species is found in such abundance. This fact must be due to biotope characteristics and/or to biogeographical phenomena. Woolly rhino had a wide distribution, from Britain in the west to north-east Siberia in the east. It is however completely absent from North America (Boeskorov 2001), indicating it did not cross the Bering land bridge.

Flerov (1967) suggested that leaves and twigs of shrubs must have been the major food source for the woolly rhino. The absence of shrubs in the late Pleistocene mammoth steppe of north-east Siberia would then have been sufficient reason why this species never reached North America, explaining its absence from the New World. However, food remains found in dental crevices and in the intestinal tract (eg in the Churapachi rhino from Yakutia; Lazarev 1977) showed that tough grasses were the major food source. Currently (Ermolova 1978; Boeskorov 2001) it is supposed that large parts of the extreme north-east were covered with hard layers of frozen snow during the late Pleistocene, hampering the spread of

Table 5.3 Terrestrial mammals (Eurogeul)

Species and skeletal part	Laboratory number	Results
Cervus elaphus, red deer, modified antler	GrA 22999*	8070 ± 50 BP
Alces alces, moose, antler	GrA 23201*	7970 ± 60 BP
Mammuthus primigenius, woolly mammoth, fragment cranium	GrN 27410[n]	37,580 −740/+810 BP
Coelodonta antiquitatis, fragment pelvic	GrN 27411[n]	39,910 −950/+1070 BP
Panthera leo spelaea, lion, ulna	GrA 23151*	42,230 −530,+570 BP
Equus cf caballus, ulna	GrA 22585*	43,550 −1050/+1200 BP
Mammuthus primigenius, woolly mammoth, fibula juvenile individual	GrA 20134*	43,800 −550/+600 BP
Canis lupus, wolf, left femur	GrA 22183*	48,400 −3300/+5800 BP

* Groningen AMS radiocarbon dating
[n] Groningen Conventional radiocarbon dating

woolly rhino to North America. It is also noteworthy that *Coelodonta antiquitatis* is absent from the mammoth fauna on the entire Taymir Peninsula.

Marine mammals

Marine taxa from the Pleistocene have been found in the southern part of the North Sea and the Eurogeul. Based on the morphology in combination with the state of fossilisation and the radiocarbon dates we may conclude that the fossils from the Eurogeul locality belong to a cold late Pleistocene fauna with harp seal *Pagophilus groenlandica*, ringed seal *Pusa hispida*, walrus *Odobenus rosmarus*, beluga *Delphinapterus leucas*, orca (killer whale) *Orcinus orca*, and grey whale *Eschrichtius robustus*.

For fossil walrus the North Sea is probably the richest source in the world. Thousands of skeletal parts and hundreds of (sometimes complete) skulls were found. Datings lie between >48,500 and 23,500 BP (Aaris-Sørensen *et al* 1990; Post 1999) indicating that walrus occurred for a long period of time (albeit perhaps intermittently). This rather southern occurrence of walrus has a parallel in the Pacific Ocean (Hoshimi and Akagi 1994). Evidently the species had a more southern distribution during the coldest phase of the last Ice Age, both in the Atlantic and Pacific Oceans.

Pleistocene occurrence of beluga and harp seal is clearly evidenced by North Sea fossils (Post and Kompanje 1995; Post 1999). Two datings of beluga (from the coast of Zeeland and the Brown Bank) resulted in 38,500 ± 800 BP (UtC 3752) and 34,600 −400/+500 BP (UtC 3753) respectively (Post 1999). Harp seal must have also occurred in vast colonies along the (Dutch) coast, but unfortunately only one fossil from the Brown Bank has been dated thus far (45,000 ± 1,500 BP (UtC 7883) Post 1999).

The coasts of the present North Sea have yielded many fossils of grey whale and proved the early Holocene Atlantic presence of this extant Pacific whale (Bryant 1995; van Deinse and Junge 1937). Fossils from the Eurogeul also confirm with certainty the late Pleistocene occurrence of this species in the Atlantic Ocean.

All species found are either bound to coastal environments (the pinnipeds), or are species that can thrive in very shallow water (beluga, grey whale, killer whale).

Molluscs

The following species of fossil molluscs were collected during the various Eurogeul expeditions:

Natica catena (Da Costa 1778)
Buccinum undatum (Linnaeus 1758)

Table 5.4 Marine mammals (Eurogeul)

Species and skeletal part	Laboratory number	Results
Eschrichtius robustus, grey whale, vertebra	GrA 22182*	>45,400 BP
Delphinapterus leucas, beluga, axis	GrA 22179*	>47,500 BP
Odobenus rosmarus, walrus, cranium fragment	GrA 22178*	>48,500 BP

* Groningen AMS radiocarbon dating

Nassarius reticulatus (Linnaeus 1758)
Mytilus edulis (Linnaeus 1758)
Chlamys varia (Linnaeus 1758)
Ostrea edulis (Linnaeus 1758)
Acanthocardia tuberculata (Linnaeus 1758)
Cerastoderma edule edule (Linnaeus 1758)
Cerastoderma edule major (Bucqoy, Dautzenberg, and Dollfuss 1895)
Cerastoderma glaucum (Poiret 1789)
Laevicardium crassum (Gmelin 1791)
Mactra corallina plistoneerlandica (van Regteren Altena 1937)
Mactra glauca (Born 1778)
Spisula elliptica (Brown 1827)
Spisula solida (Linnaeus 1758)
Lutraria lutraria (Linnaeus 1758)
Macoma balthica (Linnaeus 1758)
Venerupis aurea senescens (Cocconi 1873)
Mya truncata (Linnaeus 1758)
Zirfaea crispata (Linnaeus 1758)

The provisional malacological investigations on the Eurogeul molluscs have discovered that these molluscs are also known from the Maasvlakte, an artificial island off the coast of the province of South Holland which is partially built of sediments from the Eurogeul. A number of species from this fauna are very distinct, but we remain uncertain about their stratigraphic origin due to the lack of hard radiometric dates. Some 'warm' indicators, such as *Acanthocardia tuberculata, Mactra glauca*, and *Mimachlamys varia*, have previously been attributed to an Eemian age. However, the lack or scarcity of other typical 'warm' Eemian indicators, such as *Lucinella divaricata, Timoclea ovata*, and *Bittium reticulatum*, may indicate suboptimal climatic conditions, either from the beginning or (preferably) from the later Eemian/early Weichselian stages. The very large *Cerastoderma edule* forma *major* may also be attributed to this suboptimal climatic stage. Finally, the stratigraphic origin of the boreal-arctic *Astarte borealis*, common on the Maasvlakte, but not found during the Eurogeul expeditions, remains enigmatic. A cooccurrence with the cool *c* 50,000-year-old marine mammals reported herein cannot be ruled out. However, we tend to believe that the latter species might also represent an older cold stage.

Palynological dating of sediments and palaeoenvironmental reconstructions

Within the framework of the multidisciplinary Eurogeul investigations large pieces of sediment were recovered from the bottom of the Eurogeul area together with the bones. Subsamples of *c* 100×100×100mm were cut from 50 different pieces. Contamination was avoided by cutting undisturbed material from inside large pieces. Pollen samples were prepared of all the subsamples and their contents were screened in order to be able to date the sediments by using the palynological record from the Netherlands, and to get an impression of the existing environments. The pollen spectra were compared with Weichselian and Holocene radiocarbon-dated pollen records (Ran 1990; van Geel *et al* 1981, 1989). Two periods appeared to be represented in the sediments. Some of the samples showed the palynological characteristics of Weichselian interstadials and other samples appeared to be of Boreal age. The microfossil and macrofossil records of two examples (NRZ-1 and NRZ-2) are shown in Tables 5.5 (microfossils) and 5.6 (macrofossils) and discussed below.

Sample NRZ-1 consists of peat, mainly formed by mosses of the Amblystegiaceae. The pollen spectrum is dominated by Cyperaceae. The presence of some lumps of pollen of Cyperaceae, in combination with hyphopodia of *Gaeumannomyces* (parasitic fungus on *Carex* species; Pals *et al* 1980; van Geel *et al* 1989) points to a local occurrence of Cyperaceae. The macrofossil record shows that a species of *Carex* sect. *Acutae* was growing at the sampling site. Combined with the abundance of the mosses *Calliergonella cuspidata*, *Scorpidium scorpidioides*, *S. revolvens* and *Drepanocladus* sp this indicates an association of the Parvocaricetea. This vegetation class presently occurs in large areas of North America, north and east Europe, and Siberia (Schaminée *et al* 1995). *Scorpidium scorpidioides* is known to be abundant in consistently wet spots of particularly minerotrophic fens and the presence of *Scorpidium revolvens* indicates a quaking fen-like vegetation. Also the algae *Pediastrum*, *Botryococcus* and *Spirogyra*, combined with Types 128A and 128B (probably algal spores; van Geel *et al* 1989) point to stagnant shallow fresh water.

The extremely low amount of tree pollen reflects a treeless landscape. The number of pollen of 'dry' herbaceous taxa is very limited and their representation indicates a low diversity of the vegetation. Comparison with the detailed palynological studies by Ran (1990) point to Weichselian interstadial conditions and an age preceding the Upper Pleniglacial of the Weichselian (during which polar desert conditions prevailed), which means that sample NRZ-1 is older than *c* 26,000 BP and probably younger than *c* 50,000 BP.

Sample NRZ-2 consists of peaty clay. Arboreal taxa (mainly *Corylus*, *Pinus*, and *Quercus*) dominate the pollen spectrum. The representation of *Tilia* and *Ulmus* indicates that these trees had already migrated to the region. Comparison with a complete record of the early Holocene vegetation history in the Netherlands (van Geel *et al* 1981) points to a Boreal age (dominance of *Corylus* and absence of *Alnus*; period between *c* 9150 and *c* 7900 BP). Charred particles of botanical origin are present in the pollen slides and in the macrofossil samples. Some of the charred

Table 5.5 Percentages of macrofossils in two sediment samples from the Eurogeul

Taxa/samples	NRZ-1	NRZ-2
**Alnus*	–	0.8
**Betula*	–	3.0
**Corylus*	–	38.8
**Pinus*	0.5	24.2
**Picea*	0.5	0.4
**Quercus*	–	10.4
**Salix*	1.0	1.9
**Tilia*	–	1.5
**Ulmus*	–	3.0
*Apiaceae	–	1.5
**Artemisia*	+	–
*Cyperaceae	90.1	7.3
*Ericales	0.5	–
Fabaceae	+	–
**Humulus*	–	0.4
Iris pseudacorus	–	0.4
*Poaceae	5.4	6.5
charred cuticles Poaceae	–	+
Potentilla type	+	–
*Ranunculaceae	–	0.4
Scabiosa	+	–
Sparganium	–	5.4
**Thalictrum*	1.0	–
Typha angustifolia	–	0.8
Monolete verrucate fern spores	0.5	1.8
Monolete psilate fern spores	–	0.8
Equisetum	–	238.2
Pediastrum	10.3	0.4
Botryococcus	3.2	–
Mougeotia laetevirens type	–	0.4
Spirogyra	1.6	0.4
Type 128A	6.5	2.7
Type 128B	0.5	0.8
Rivularia type	–	0.4
Gaeumannomyces, hyphopodia	2.2	–
Ustulina deusta, ascospores	–	0.8
charred particles	–	++

Taxa included in the pollen sum (base of percentage calculations) have been marked with an asterix.

microfossils were recognisable as cuticles of grasses (Poaceae). Mesolithic people may have been responsible for fires while creating open hunting areas, but we cannot exclude the possibility of natural fires. Local taxa indicate shallow fresh water which was in a phase of terrestrialisation, considering the dominance of *Equisetum* (spores and vegetative remains) together with *Alisma plantago-aquatica*, *Eupatorium cannabinum*, *Iris pseudacorus*, *Mentha aquatica*, *Phragmites australis*, *Sparganium*, *Bythinia*, *Cladocera*, fresh water sponges, and algae (*Spirogyra*, *Mougeotia*).

Evidence of Holocene human occupation of the Eurogeul locality

The surroundings of the present day Eurogeul, as part of the southern North Sea, were inhabited by terrestrial and marine mammals during the late Pleistocene, and terrestrial mammals during the early Holocene. Moreover, during this period there is conclusive evidence of the presence of humans in this area.

Sophisticatedly carved tools made from red deer antler and auroch bone (metapodals) (see for example Louwe Kooijmans 1970–71), definitely Mesolithic material, have been salvaged from the bottom of the southern North Sea. Many other finds imply that Mesolithic people hunted moose, horse, and wild boar as well in this area. Recent finds which have been radiocarbon-dated confirm this hypothesis (Post 2000; Glimmerveen *et al* 2003) (see Table 5.7 for radiocarbon dating on wild boar). In addition, radiocarbon dating of two recently found samples of red deer phalanxes confirms that this animal inhabited the North Sea Basin during the same period as Mesolithic people did (see Table 5.7 below).

Recently three artefacts made of red deer antler have been fished from the bottom of the Eurogeul. Since these artefacts are fresh and bear no marks at all of secondary transportation, we may conclude that the artefacts were found more or less *in situ*. Radiocarbon dating of one of these artefacts (the first dating in Table 5.3) constitutes further proof for the coexistence of Mesolithic people and red deer in the southern North Sea and in the area of the Eurogeul in particular. This modified antler of the Mesolithic period can be placed in the Boreal (*c* 9150–7900 BP). All three artefacts, which are quite similar, match other artefacts of red deer antler found elsewhere on the bottom of the southern North Sea and with finds on both sides of the North Sea in Great Britain and on the continent especially in the Netherlands (see for example Louwe Kooijmans 2001). Mesolithic people often used antler as raw material for their tools and they almost exclusively used antler from red deer.

Table 5.6 Macrofossils (presence/absence) in two sediment samples from the Eurogeul

Taxa/samples	NRZ-1	NRZ-2
Alisma plantago-aquatica, fruits	–	+
Carex pseudocyperus, perigynium	–	+
Carex rostrata / vesicaria, achenes	–	+
Carex vesicaria, perigynia	–	+
Carex sect. *Acutae*, achenes	+	–
Eupatorium cannabinum, fruit	–	+
Mentha aquatica, achenes	–	+
Myrica gale, fruit	–	+
Phragmites australis, seeds	–	+
Ranunculus flammula, achenes	–	+
Typha, seeds	–	+
Equisetum, vegetative remains	–	+
Calliergonella cuspidata, leaves	++	–
Scorpidium scorpidioides, leaves	++	–
Scorpidium revolvens, leaves	+	–
Drepanocladus sp., leaves	+	–
Acari	+	–
Bryozoa, statoblasts	–	+
Bythinia, opercula	–	+
Cladocera, ephippia	–	+
fresh water sponges, gemmules	–	+

The findings and the palynological data prove that Mesolithic people lived and, probably, hunted in various ways in the surroundings of the present day Eurogeul as a part of the forested environments the southern North Sea Basin which formed the habitat of red deer, *Cervus elaphus*, and wild boar, *Sus scrofa*.

Discussion and conclusion

Based on data of beluga and walrus fossils from the North Sea floor and recent radiocarbon dates on North Sea specimen of the mammoth fauna we may deduce that marine as well as terrestrial mammals, albeit with intervals, were present in

Table 5.7 Results of ^{14}C dating of North Sea red deer, wild boar, and *Homo*

Sample name	Laboratory number*	^{14}C age (BP)	sigma	Geographical coordinates
Cervus elaphus				
GL01, Second Phalanx	GrA 20353	8350	50	52°27′ N, 02°55′ E
GL04, First Phalanx	GrA 20256	8820	60	52°22′ N, 03°06′ E
Sus scrofa				
No.2684, Humerus	UtC 7886	9450	70	Southern Bight North Sea
Homo sapiens				
Mandibula	GrA 23205	9870	70	Southern Bight North Sea
No.1063, Cranial bone	UtC 3750	9640	400	52°10′ N, 02°49′ E
Cranial bone	?	8340	130	Southern Bight North Sea
Mandibula	GrA 11642	8370	50	53°00′ N, 02°54′ E

* GrA – Groningen AMS; UtC – Utrecht AMS

what is now the Southern Bight of the North Sea between the British Isles and the Netherlands from 44,100 to 28,000 BP. Therefore we must conclude that, at least for a part (or parts) of this period, marine and terrestrial mammals were contemporaneous.

Based on the first few data of terrestrial mammals of the mammoth steppe ecosystem from the Eurogeul we may conclude that events were (at least partly) parallel those in other parts of the Southern Bight of the North Sea. Palynological investigation supports this conclusion.

However, as yet we cannot draw the same conclusion for the marine mammals. Although the marine species found in the Eurogeul correspond with those from the North Sea and belong to a cold late Pleistocene fauna as well, radiocarbon datings provide no conclusive evidence. Perhaps surprisingly, provisional malacological investigations do not show marine taxa from this period either.

Although the Eurogeul investigation has only just begun to produce its first, still limited, data, we are developing a very interesting and rather spectacular hypothesis for further investigations. This hypothesis is that the site was part of the Rhine-Meuse delta system, a large estuary fading out in a shallow North Sea. Marine mammals, such as pinnipeds, beluga, and grey whale could easily enter this system and their remains must have been deposited together with carcasses of terrestrial mammals, such as the woolly mammoths and woolly rhinoceroses, which were caught for whatever reason by the river system.

The Eurogeul area was inhabited by terrestrial mammals and by people during the early Holocene, especially the Boreal, as palynological investigations, and palaeogeographical and archaeological evidence demonstrate. As yet we only have limited (though conclusive) evidence. Here too we need further investigations in order to be able to compare with continental cultures and to explore the possibility of a Palaeolithic human presence in the area and to answer the question of whether people were part of the mammoth fauna too.

The first results of the expeditions and investigations are encouraging and show the necessity and the intriguing possibilities of further multidisciplinary investigations.

Acknowledgements

We are grateful to Mr Bernard Buigues (Saint Mandé, France), General Director of CERPOLEX, for providing funds which enabled us to make several expeditions on the Eurogeul. Dr Cees Laban (Utrecht, the Netherlands), NITG-TNO, for providing information on the geology of the Southern Bight of the North Sea. Dr Frank Wesselingh and Mr Anton Jansse (Leiden, the Netherlands), National Natural History Museum, Naturalis, for their participation in the research project on the Eurogeul and their contribution on the molluscs. We would like to express our gratitude to the members of the crew of several beam-trawlers from the fishing fleet in the harbours of Stellendam, Vlissingen, Breskens, Scheveningen, Oude Schild, and IJmuiden who provided us over the years not only with Pleistocene mammal remains but also with locational information. As an example between 1997–2003 we collected from these fishermen approximately 60,000 kilos of bones (of both small and larger mammals) and about 8000 molars of woolly mammoth. Last, but not least, we thank skipper Maarten de Waal and his crew for the outstanding operations on the North Sea with the fishing vessel *De Hinder* (GO 33).

6 Submerged Stone Age coastal zones in Denmark: investigation strategies and results

by Ole Grøn and Jørgen Skaarup

Abstract

Excavation of submerged prehistoric sites by diving archaeologists shows that it is possible to obtain degrees of high resolution stratigraphic information comparable to excavation on dry land. Many sites have been eroded so that the remaining deposit has been disturbed and concentrated, but a few sites are completely intact. Examples are given of different sites, and the use of acoustics followed by diving excavation.

Introduction

Systematic excavation of submerged Stone Age sites was initiated in Denmark in 1976 by Langelands Museum. Since then systematic surveys for, and excavations of, such sites have been carried out by this and other Danish institutions (Skaarup 1983, forthcoming). A number of methods and strategies have been tested, and some experience — some rather costly and difficult to obtain — has been gained (Grøn 1990, 1996).

One of the first and most important findings is that the sea floor is not an unlimited paradise of Mesolithic and Neolithic landscapes with well-preserved settlement remains. Sounds and channels with currents that work their way down through the glacial clays alternate with areas where deep sedimentation makes it extremely difficult to locate and investigate the well-preserved landscape surfaces. Only in a few areas are these both preserved and easy to access so that investigation can be carried out under controlled circumstances.

A second finding is that we must accept — in spite of the significant technological advances that have been made in recent years with regard to survey methodology — that there are limitations to the areas where these innovations can be applied successfully. A reasonable response seems to be to focus investigation and preservation strategies in the areas allowing the use of the new technologies, and to develop a series of meaningful investigation and preservation strategies for the remaining areas. One should, however, take into account that pockets with good preservation can appear in the most unexpected situations.

To demonstrate the potential of marine archaeology, a Mesolithic dwelling and a boat burial (early Ertebølle culture) excavated by Langelands Museum in the period 1990–93 will be briefly presented later in this paper. To underline the importance of the development of an investigation and preservation strategy for locating and dealing with such finds, the next section outlines the strategic thinking as developed at the museum in the 80s and 90s.

Investigation, survey, and management strategies

Recognising the potential of the well-preserved submerged Mesolithic and Neolithic landscapes in the South Funen Archipelago, in 1972, Langelands Museum started a systematic registration and monitoring of submerged cultural heritage sites from the Mesolithic and Neolithic in collaboration with sports divers from the Funen area (Skaarup 1983). In 1983 43 submerged Stone Age settlements were registered in this area. In the total Funen area — the museum's present area of marine archaeological responsibility — 126 Stone Age settlements have been registered to date (Skaarup, forthcoming).

The excavation of the submerged kitchen midden Møllegabet I (Skaarup forthcoming) started a development of excavation technology that in time led to an investigation approach close to that employed on dry land. The large areas with Stone Age tree stumps preserved and exposed on the seabed made it natural to start thinking in terms of the reconstruction of prehistoric cultural landscapes. A survey of different parts of the South Funen Archipelago carried out by Jørgen Dencker and Ole Grøn in 1986 showed that the most promising area for a cultural landscape study comprised two apparently intact lake basins with a shoreline around −4.5m, submerged in the Sub-Boreal, and the zone around them.

Seismic profiling of the southern of the two basins (Fig 6.1) was carried out in collaboration with Professor Jens Tyge Møller, Aarhus University, in the period 1989–91. A series of borings were carried out, and one palynological profile was analysed by Else Kolstrup to calibrate and interpret the seismic profiles. This effort revealed that the banks of the approximately 15 × 15km large basin consisted of a several-hundred-metre-wide and generally 2m-thick layer of peat and gyttja surrounding the 6–8m-deep central part of the basin. The erosion of the peat and gyttja layers

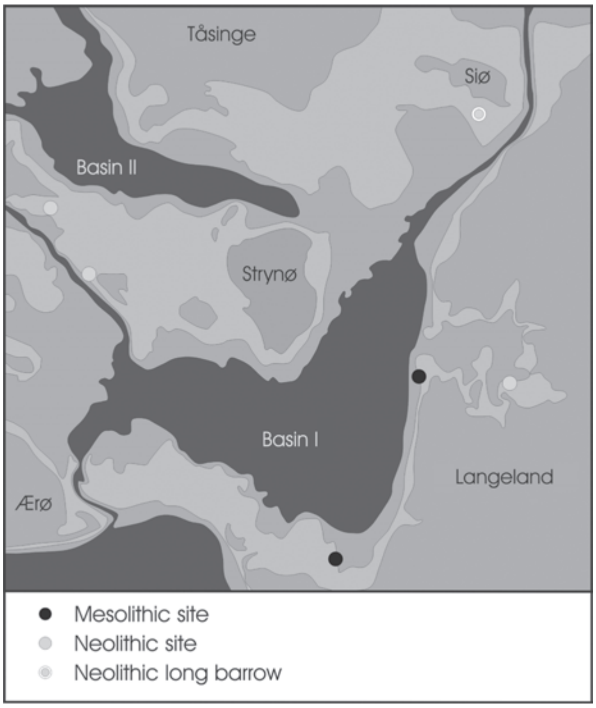

Figure 6.1 The two submerged lake basins in the central South Funen archipelago

and the more recent sedimentation covering them seems minimal. There is some erosion and deposition of sandy sediments near the Ristinge barrier, but it appears that large and undisturbed areas with good conditions for preservation of organic matter are retained in the basin, which contains registered Mesolithic and Neolithic sites.

One problem identified is the difficulty of locating the sites that are not eroded — and therefore are especially valuable. The dual frequency 'Sounding 30' sediment echo-sounder owned by Aarhus University was not able to distinguish layers with the characteristics one would expect Mesolithic cultural layers to have. A second problem was that the Decca navigation we had access to with its ±25m tolerance was far too imprecise to register and relocate smaller features observed in the seismic profiles (Grøn 1990). Initial funding for the landscape project had been provided by Niels Højlund's Culture Foundation. The project came to a halt because funding to follow up the initial results could not be obtained.

In the period 1993–96 Ole Grøn had (as part of the Danish National Museum's Centre for Maritime Archaeology) the opportunity to develop a survey technique based on a 2–22kHz chirp from Datasonics and an Ashtech DGPS navigation system, which to a reasonable degree solved the two basic technical problems. The defined focus of the project was features younger than the Stone Age (Bronze Age, Iron Age, Viking Age, and medieval), but it was demonstrated that the partly excavated culture layer from the Kongemose site Blak in the Roskilde Fjord was clearly visible in the recordings (Fig 6.2) (Grøn *et al* 1998).

Even though the technological basis for a systematic survey and monitoring of submerged prehistroic landscapes and sites is far from fully developed, a useful basis has been created.

The excavation of a submerged Mesolithic dwelling and a boat grave

In 1990–93 Langelands Museum excavated at Møllegabet II, a submerged Mesolithic dwelling and a boat grave outside Ærøskøbing in the South Funen Archipelago.

The remains of a skeleton of a young man lay in and around the remains of a dugout (the dugout dated to K5640:4900–4730 cal BC and the skeletal remains in it to K6040:5230–4960 cal BC). A number of poles apparently related to the feature may originally have supported it so that it was located above the water (Grøn and Skaarup 1993; Skaarup 1995; Skaarup forthcoming).

The dwelling (K6681: 5280–5140 cal BC and K6682: 5280–5080 cal BC) was located in a pit, approximately 5×3m large and 200mm deep,

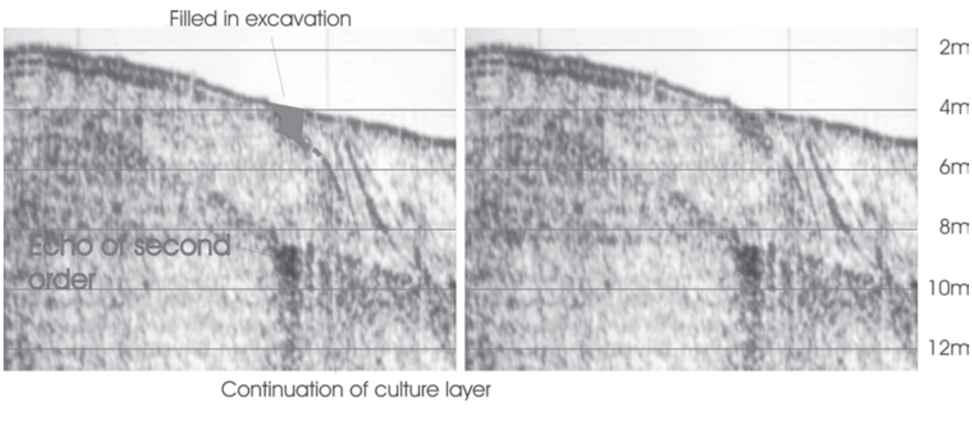

Figure 6.2 Section through the partly excavated Kongemose site Blak in Roskilde Fjord. The stratigraphic layer registered in the excavated area can be followed outside it embedded in sandy gyttja. Recording Ole Grøn 1996

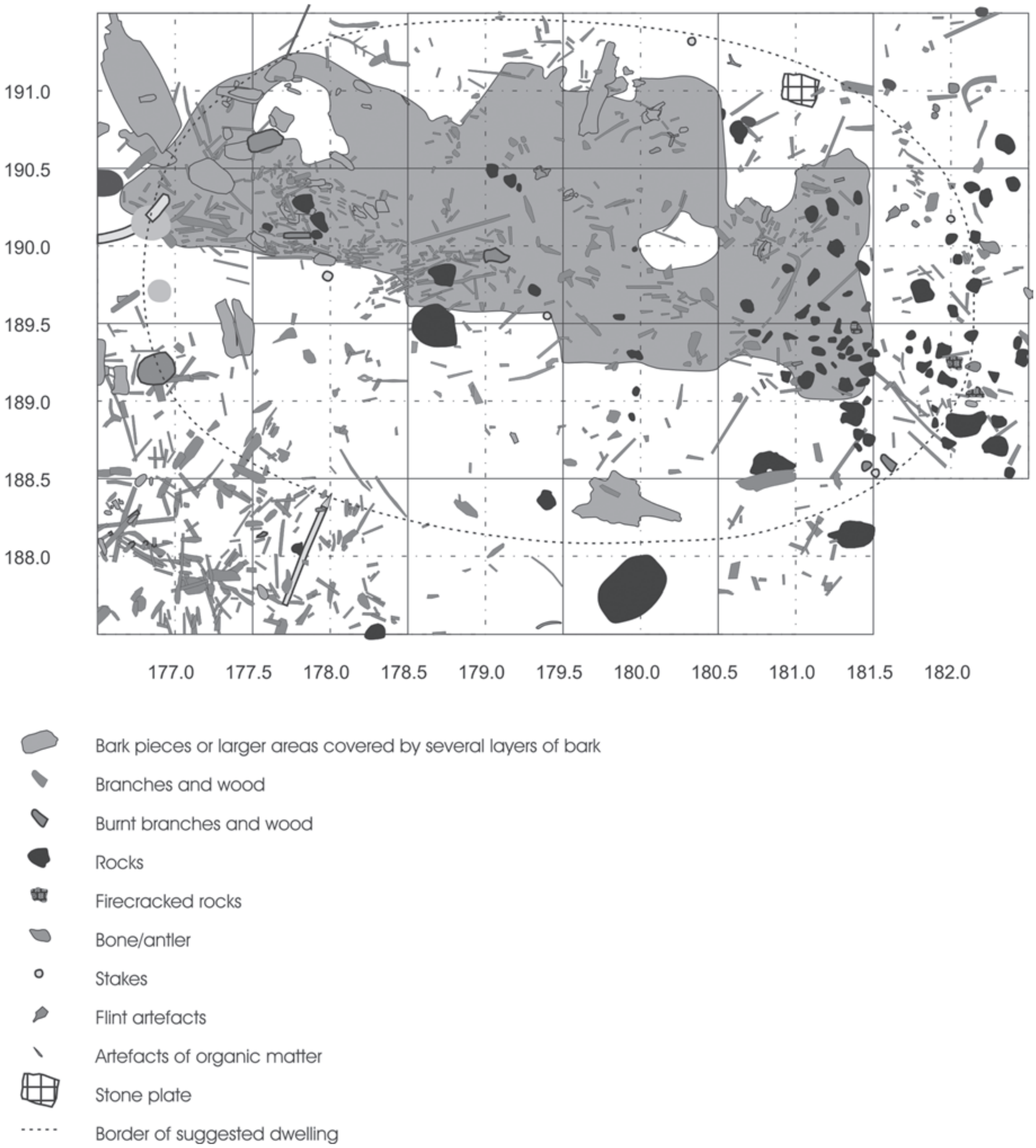

Figure 6.3 Plan of the early Ertebølle dwelling excavated at Møllegabet II

with the lower parts of some wall stakes and two inner stakes preserved. A coherent layer of bark pieces covered the northern half of the dwelling — a feature that in section appears to be an earth-built platform. The floor and the platform were covered by twigs and bracken leaves, and the front of the platform seems to have been supported by cloven hazel branches (Figs 6.3 and 6.4).

The two inner stakes were located adjacent to the two areas interpreted as hearths just in front of the platform, and the door seems to have been in the western end, from where the sea could be observed.

The excavation of the site in 500×500mm squares and 50mm layers allowed a detailed reconstruction of the activity patterns in the dwelling. Below the platform there appear to be two working places where flint-knapping and repair of hunting weapons were carried out. Furthermore two proposed women's seating places were distinguished on the platform (Grøn 1995a, 2003). A fifth area just inside the proposed entrance seemed atypical as a regular personal seating area, but may have been a position that was used by visitors or by inhabitants when they wanted to observe the nearby sea.

On the basis of studies of dwelling organisation in hunter-gatherer societies, on archaeological material and ethnoarchaeological studies in Siberia, the dwelling has been interpreted

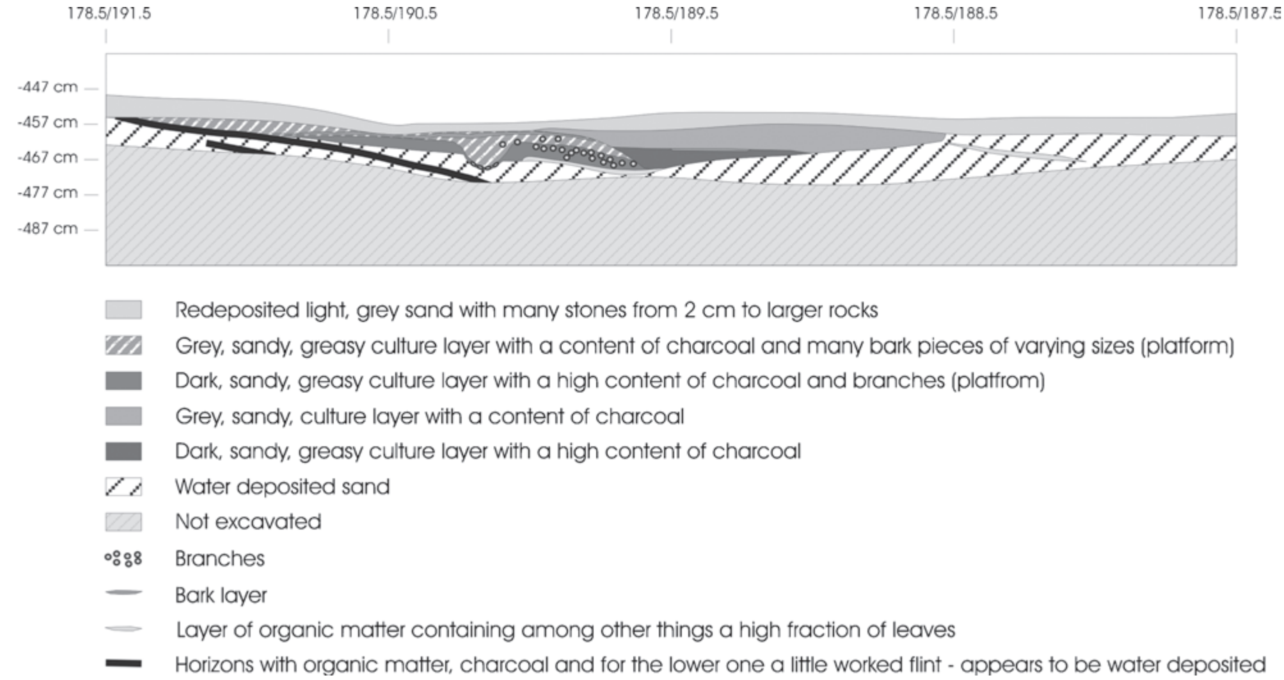

Figure 6.4 N–S section through the dwelling pit showing the earth-built platform

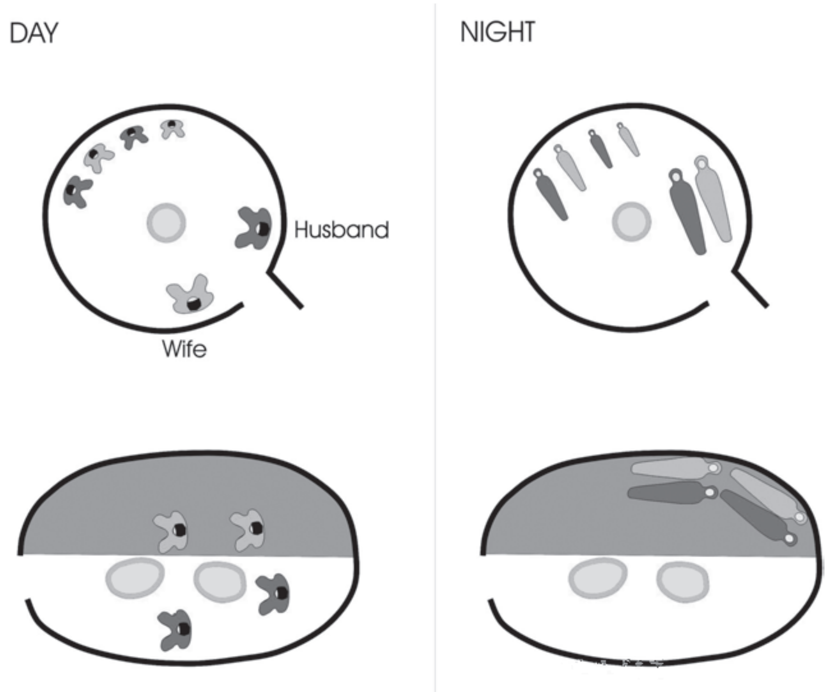

Figure 6.5 Upper: the dwelling organisation found with the Evenki reindeer hunters in Siberia. Lower: the dwelling organisation suggested for the early Ertebølle dwelling excavated. Shade code: ▭ = females; ▭ = males; ▭ = bark-covered platform; ▭ = hearth

as a two-family dwelling (Fig 6.5) (Grøn 1989, 1995a, forthcoming; Grøn and Kuznetsov 2003).

Conclusion

This paper demonstrates that it is possible to develop methods for locating and monitoring submerged Stone Age sites and landscapes in areas with good preservation that facilitate the application of acoustic techniques. It also shows that the submerged cultural heritage can elucidate aspects of prehistoric life that are difficult to address on land. Therefore the development of systematic and coherent strategies for the management of this cultural resource is of extreme importance.

7 The implications of prehistoric finds on and off the Dutch coast *by Leo B M Verhart*

Abstract

This paper presents a brief overview of the prehistoric finds from the North Sea. The oldest finds date from the middle Palaeolithic, the youngest from the Mesolithic. The lack of Mesolithic flint attributed to settlement activities is surprising. In an attempt to explain this lack, a survey is carried out of dry land Mesolithic behaviour in the southern part of the Netherlands.

Introduction

The harsh environment of the North Sea differs significantly from the shallow waters around the Danish Isles. In the Danish waters some sites are perfectly preserved and rather easy to excavate (Fischer 1995). Underwater excavations of prehistoric sites are lacking in the Dutch part of the North Sea. So far we have only dredged up some finds during fishing activities. These mainly date from the Mesolithic and I will concentrate on this period.

What can we do with these scattered finds with hardly any contextual information? Do they give us clues for future research on the floor of the North Sea? In this short paper I want to present these finds and try to reveal something of their background. My next step will be to present some brief information about Mesolithic behaviour on dry land and what the prospects will be for research in the North Sea with that information in mind.

A history of fishing and gathering

The earliest find from the North Sea is the barbed point discovered during fishing activities around the Leman and Ower Banks in 1932 (Burkitt 1932). In the late 1960s and early 1970s a new Mesolithic fishing location was discovered. Around the Brown Bank fishermen discovered bones of Pleistocene age in their nets and among these Mesolithic bone and antler artefacts were also recognised (Louwe Kooijmans 1971–72). These consisted of waste from bone-working, implements such as a pick with shaft hole, socketed adzes (Fig 7.1). and a perforated mace head. The composition of the finds suggests settlement background. So far no flint has been found. On the eastern coast of Great Britain some barbed points were also found, but these were discovered on beaches (Mellars 1970; Saville 2001).

In the 1970s a new find location was discovered. Due to the construction of a new harbour and artificial land extension at Europoort, near Rotterdam, amateur archaeologists and palaeontologists had the opportunity to collect masses of fossilised bones from several faunal stages of the Pleistocene. They also gathered implements from the Mesolithic on the beaches. The composition of finds is completely different from that of the Brown Bank. More than 90% of the artefacts are barbed points made of bone and antler (Louwe Kooijmans 1971–72; Verhart 1988, 1995). At the moment the total number of finds is around 500. Two groups of points can be distinguished (Fig 7.2). Small points with tiny barbs were probably used as arrowheads, and long points with wide-spaced barbs may have been used for fishing and hunting large animals. The total lack of worked flint and implements which could be attributed to settlement activities is remarkable. The finds themselves and the absence of flint suggest that we are dealing with lost hunting gear (Verhart 2000b).

There are two important parallels for this find group in western Europe. In the Danish Åmosen (Andersen 1983; Mathiassen 1943) and German Havel region (Cziesla 2000; Gramsch 1973) identical find groups have been found. These are also interpreted as lost hunting gear in former lakes. An identical interpretation for the Europoort finds as lost hunting equipment preserved in lake sediments is likely.

Due to coastal defence works the beaches have been raised with large amounts of sand and dune areas have been fortified over recent years. The sand was dredged up from various locations off the Dutch coast. On the exposed beaches amateurs collected a small amount of finds at different locations (Verhart 1995). They found bone and antler points, similar to the Europoort finds, but also more heavy implements such as axes with shaft holes, and some waste products from bone-and antler-working.

Very recently much older finds were recovered from the North Sea. In 1999 artefacts were collected in heaps of debris from shell-fishing close to the Dutch coast (Verhart 2001). Apart from large amounts of fossil bones, Mesolithic bone implements, waste of bone-working, and many flint artefacts were gathered. Most flint artefacts are flakes, blades, some cores, and a scraper. Most surprising was the discovery of hand axes (Fig 7.3). The weathered surface of most of the artefacts, the flint technology, and the hand axes, all indicate a middle Palaeolithic date for the

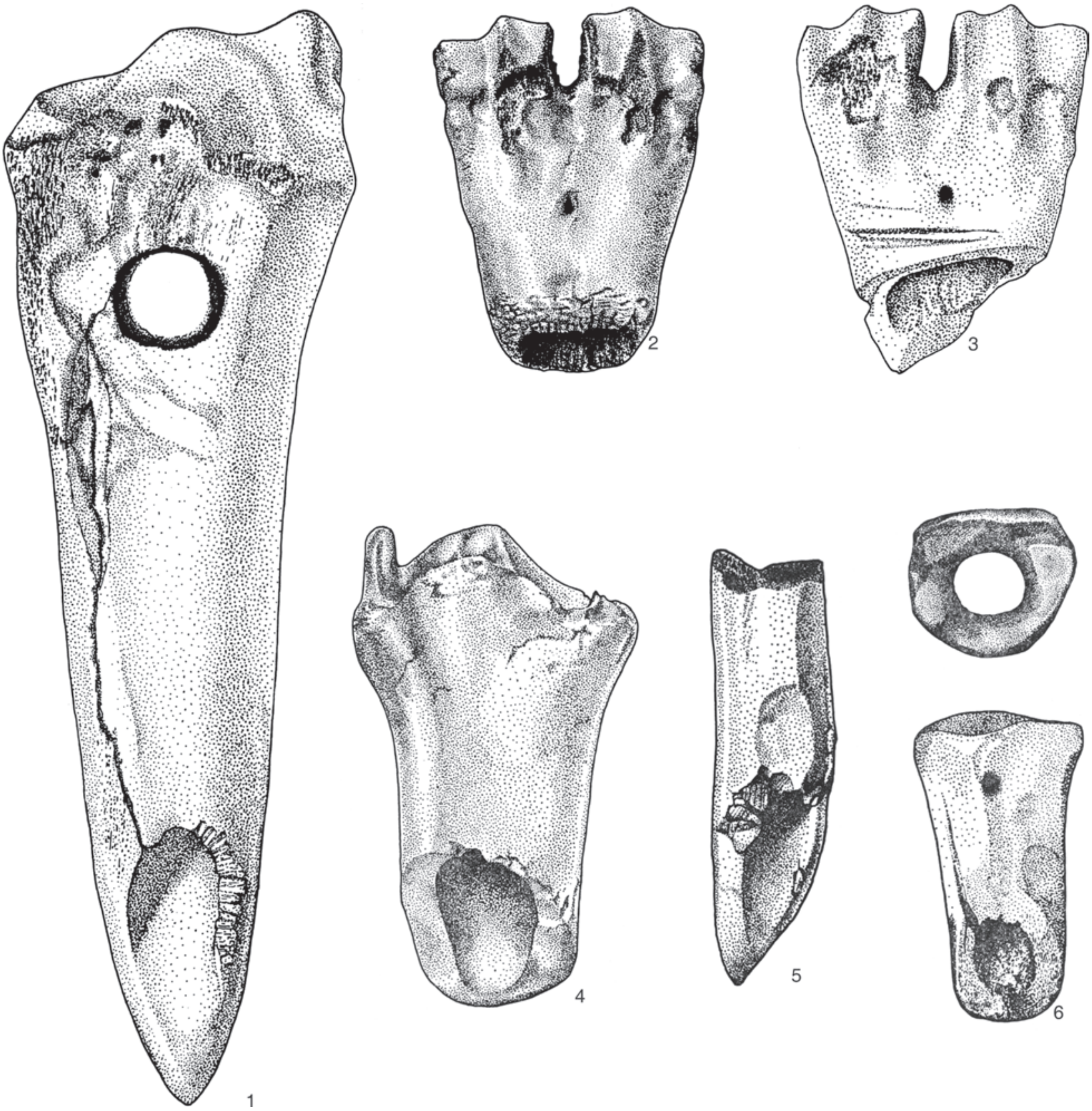

Figure 7.1 Bone implements discovered at the Brown Bank (scale 1:2)

Figure 7.2 Small bone and antler points from Europoort. Lengths of the largest point 82mm

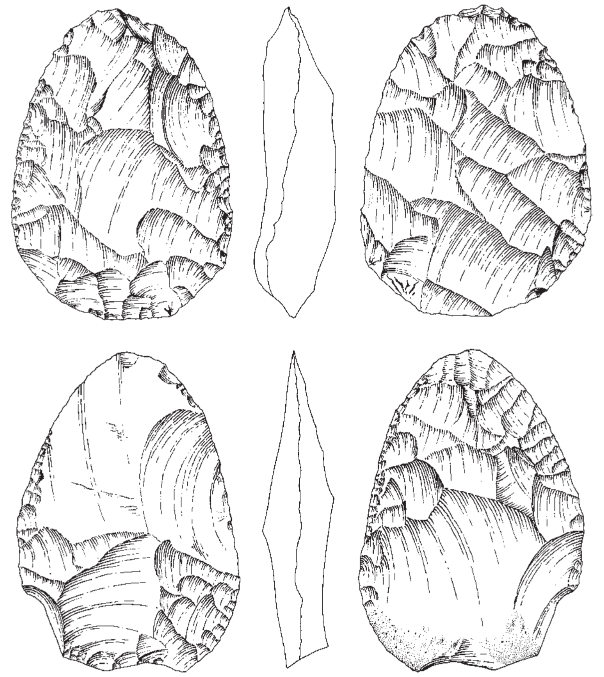

Figure 7.3 Hand axes from Zeeland. Above: length 98mm, below: 97mm

finds. In the last few years more hand axes have been collected (Glimmerveen, pers comm).

The yield of the sea floor

The artefacts from the North Sea and the composition of tools are the only sources of information we have for the reconstruction of the Mesolithic habitation and behaviour in this area. It is very remarkable that we do not have any identifiable Mesolithic flint from the floor of the North Sea at this stage, while large amounts of natural flint have been collected by amateurs.

Apparently the places which yield Mesolithic artefacts must have been areas with good conservation conditions. Bone and antler are well-preserved. The lack of finds which can be attributed to settlement activities indicates that habitation areas have not yet been located. The main questions are do these areas still exist deep down on the bed of the North Sea and can they be located?

Over the last decade new regional information about the Mesolithic from the dry parts of the

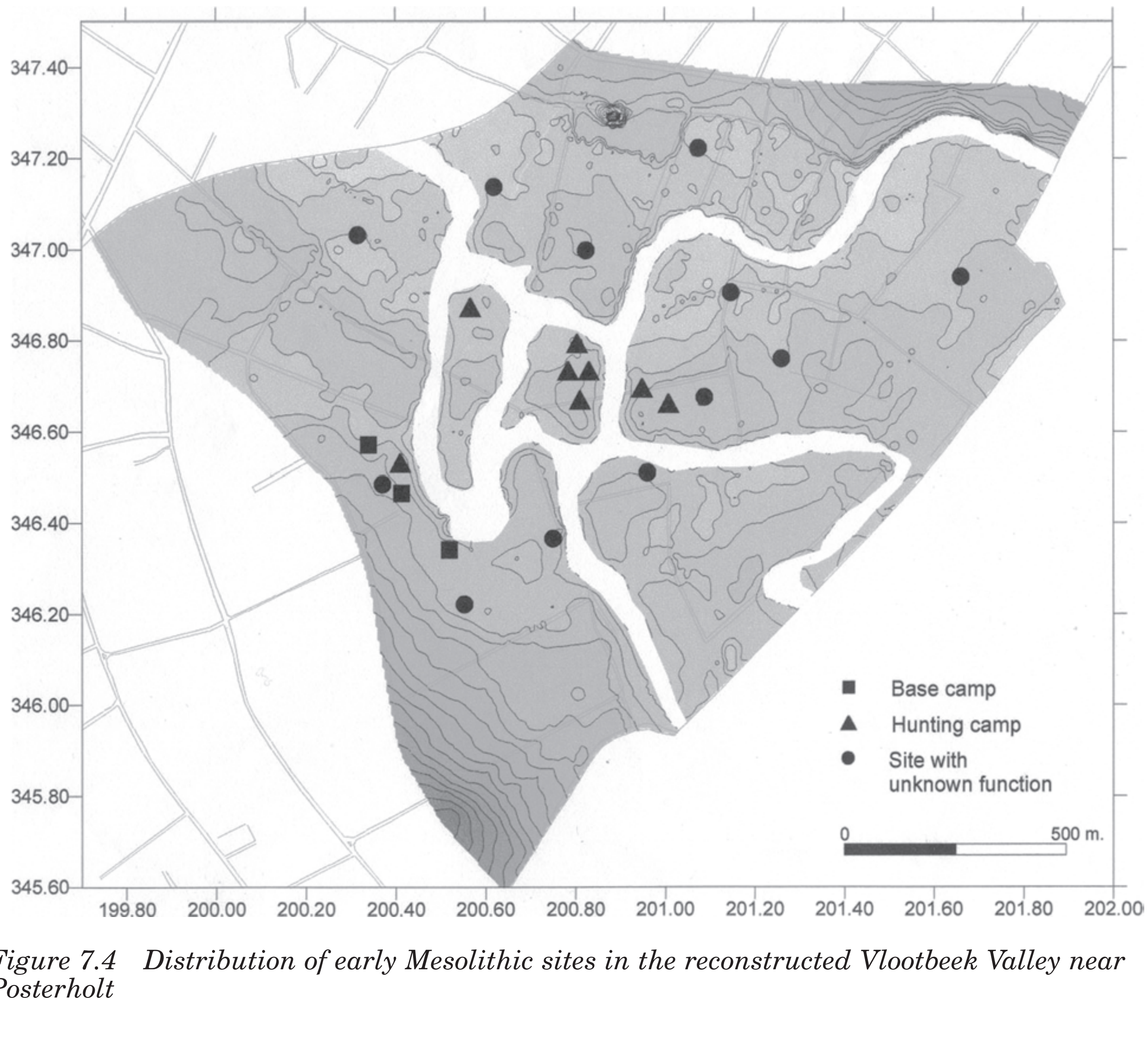

Figure 7.4 Distribution of early Mesolithic sites in the reconstructed Vlootbeek Valley near Posterholt

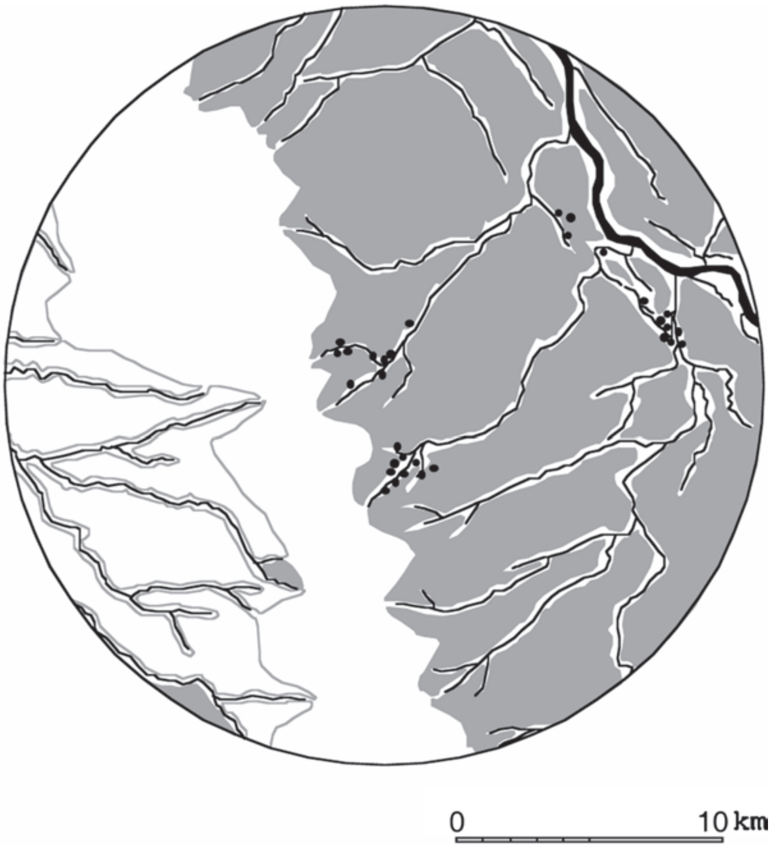

Figure 7.5 Simplified reconstruction of the late Mesolithic landscape and distribution of sites near Venray. White: peat and open areas along brooks and rivers; grey: forest

Netherlands has become available. Patterns of habitation and settlement organisation can be reconstructed which could prove useful in predicting site location on the sea floor in the future.

Dry land Mesolithic behaviour

I want to present the results of two small regional projects in the south of the Netherlands. In Middle Limburg, close to the village of Posterholt, the small valley of the Vlootbeek has been surveyed over the last 30 years (Verhart 2003). In addition some sites have been excavated. In the valley a distinctive pattern of early Mesolithic occupation can be observed (Fig 7.4).

The valley of the Vlootbeek is actually the late glacial stage of the River Roer. Early in the Holocene the river changed its course, thereby preserving almost the entire valley. Field investigations recovered 25 early Mesolithic sites. Younger Mesolithic sites are absent.

A twofold division in settlements can be discerned. Small sites with predominant points are located on small islands in the valley itself, indicating the existence of hunting camps. Larger sites with a tool composition which can be classified as domestic are located on the embankments of the valley. These sites are interpreted as base camps.

The valley of the Vlootbeek demonstrates a remarkable pattern of small, short-lived hunting camps on islands in the valley and on the shores. Base camps, however, occur exclusively on the higher embankments.

The second regional project is situated more to the north, close to the town of Venray (Verhart 2000a). A palaeogeographic reconstruction of the terrain provides a picture of dense forest vegetation on the coversands. There is an eastern part dominated by the valley of the River Meuse with a more open vegetation and a western part with a high peat bog, which had a rather open vegetation. The distribution of late Mesolithic sites shows a striking pattern (Fig 7.5). There is a cluster of sites at the transition between coversands and the river valley in the east. A second cluster is located in the west at the source of the streams, at the exact transition between the peat bogs and the coversand area. The tool composition of the surface sites dating from the late Mesolithic is almost identical. At all sites points, scrapers, backed blades, and retouched blades/flakes are present in almost equal proportions. Projectile points are often present in somewhat greater numbers. There is no single dominant tool category. The excavation of one of the sites revealed that these sites can be interpreted as small, relatively short-lived base camps, where a wide range of domestic activities took place, but where hunting was the most important activity.

These examples demonstrate that Mesolithic sites can be expected in a specific type of terrain. The majority of the sites are situated at the borders of geographical units, at the transition of different ecological zones. If it is possible to reconstruct the prehistoric landscape on the North Sea floor, we will have an opportunity to specify areas where we can expect Mesolithic settlements.

Final remarks

At the moment only Mesolithic finds from locations with perfect preservation conditions are known from the North Sea floor. Those finds are interpreted as lost hunting gear, but hardly contribute to the reconstruction of behaviour by Mesolithic people in the North Sea region. The Mesolithic settlements are lacking up until now. I propose a strategy to locate those settlements by reconstructing in detail preserved and drowned landscapes. That will be a difficult and expensive operation.

Excavations will be much more expensive. I think it is only worthwhile to excavate these settlements when they have been used for a short period of time and where we can expect to find organic material as well. The study of Mesolithic sites in the southern part of the Netherlands has revealed that most sites were frequently visited by Mesolithic people, sometimes over periods of several thousand years. At the moment it is impossible to reconstruct the separate activities at these mixed sites. I think we will be confronted with identical problems when we want to excavate such sites on the North Sea floor. So we have to start focusing on briefly used sites.

Considering the wide and open sea, the harsh environment, the gigantic equipment for exploring the North Sea and the enormous amount of money involved, we have to keep in mind that small is beautiful.

Section 3 Systematics, palaeontology, and proxy data

North Sea trawler showing construction of the two bottom beam trawl nets (©: CERPOLEX/ Francis Latreille)

8 Investigating 'Doggerland' through analogy: the example of Holderness, East Yorkshire (UK)

by Henry P Chapman and Malcolm C Lillie

Abstract

The early Holocene occupation of the North Sea Plain (or Doggerland) remains poorly understood due to both a paucity of archaeological remains, and an incomplete model of physical landscape change in terms of the many geomorphological and palaeohydrological processes in this region. In this context, it has been recommended that dry land areas adjacent to Doggerland may be appropriate foci of study to enable the construction of predictive models of human activity patterns in the submerged areas. In this paper, the case for Holderness in East Yorkshire (UK) is presented as a suitable landscape for analogous study of Doggerland during the earlier Holocene. A preliminary approach to investigating the potential for contemporary perception of environmental change is presented. The conclusions from this work re-emphasise the value of Holderness for providing a hypothetical model for understanding landscape change in the early Holocene of the North Sea Basin, and assessing its cultural and perceptual implications.

Introduction

Towards the end of the Devensian, and into the early Holocene, the melting of the ice sheets and warmer sea temperatures led to rapidly rising sea levels and the consequent flooding of large areas of low-lying landscapes, including the separation of present-day Britain from mainland Europe. An increasing corpus of research related to the nature of the submerged North Sea Plain, or 'Doggerland' (thus named by Coles 1998), is being generated (eg Coles 1998, 1999; Shennan and Andrews 2000; Shennan *et al* 2000a and b). This work has highlighted some of the shortcomings and concomitant difficulties of modelling such extensive landscape change during the late Quaternary. However, despite this, a number of papers have attempted to reconstruct the evolution of the North Sea Basin throughout this period using 'time slice' mapping (eg Verhart 1995; Coles 1998). In the case of Coles (1998), the resulting maps postulated the nature and extent of dry land areas and the positions of rivers at different times throughout the period. The study was referred to as 'speculative' in that it was predicted that future work 'may invalidate rather than support much of this ... survey of Doggerland' (Coles 1998, 77). Indeed, more recent investigations have produced new models of the North Sea Basin that differ markedly from the 'speculative' work of Coles (eg Shennan *et al* 2000a).

The current discussion is not restricted to the physical changes to the North Sea Basin throughout the Quaternary. Recent research has also considered and debated conceptual understandings of the landscape. It has been argued that the 'Doggerland' landscape represented a living space (Coles 1998, 1999) rather than merely a 'land-bridge' connecting Britain to mainland Europe (Jacobi 1976). However, the more common cultural perspective considered to date relates primarily to the implications of the separation of Britain from continental Europe rather than the cultural significance of this landscape (eg Evans 1975; Mithen 1999). Consequently, the effects of significant landscape changes on such a large 'living space' have not been investigated in any detail. Essentially, it has been noted that periods of relative stasis might have been followed by dramatic, perhaps catastrophic, inundation (Coles 1998), but that the degree and nature of such changes are yet to be explored.

The effects of environmental change on the individuals and communities of the North Sea Basin, and their perception of such change, is difficult to evaluate in relation to the macro-scale landscape. Whilst elements of geomorphological change are crucial to our understanding of the North Sea Basin, any attempt at estimating the perception of such changes by contemporary individuals and communities on the ground should be considered in relation to the micro- or meso-scales (ie the site or its immediate landscape). However, such analyses will remain difficult to address since the submerged landscape has potentially been subjected to considerable morphological change, through processes of sediment erosion and accretion. This paper examines the suitability of Holderness as a proxy hypothetical landscape for the investigation of 'Doggerland' by analogy, begins to explore the ways in which it can be analysed, and assesses to what extent contemporaneous populations could have perceived landscape change during the earlier Holocene.

Holderness as an analogy

Coles has suggested that future geological work could be used to model predictively site location for further investigative work 'based on our increased knowledge of site selection in adjacent regions' (Coles 1998, 77), thereby emphasising the importance of investigation into those areas of dry land on the margins of the North Sea Basin. This perspective is emphasised by an earlier paper that highlighted how difficult it would be to reconstruct life on 'Doggerland' during the Mesolithic from the poor quantity of available data (Verhart 1995). The approach recommended by Coles (1998) stressed the need to gain insights into accurate site location through the generation of predictive models based upon data generated in adjacent dry land (accessible) areas. This modelling would also feed into our logistical understanding in terms of the three-dimensional position of sites within sediment matrices.

Consideration of dryland analogies for approaching cultural interpretations of Doggerland has been described previously: 'The shifting, changing wetlands of the Wash and its hinterland in later millennia may offer something of an analogy for conditions in Doggerland's lowlands, particularly inland of the north coast and the major estuaries' (Coles 1998, 66).

However, while such comparisons might assist in our understanding of the physical nature of the Wash during this period, they are less useful when attempting to understand the early Holocene landscape of the region due to excessive sedimentary accretion and coastal change (Brew *et al* 2000). Other dry land analogies have also been criticised as being inappropriate for cultural study, for instance according to Verhart, 'Comparable sites that were not flooded by the North Sea simply do not exist in the Netherlands' (Verhart 1995, 291).

In light of the broader definition of the topography of Doggerland provided by Coles we may be able to provide a more appropriate example for study as: 'Other features of Doggerland will have included glacial moraines, kettle holes, gravel banks, numerous lakes and wetlands and minor hills' (Coles 1999, 52). On the basis of this description, the landscape morphology has been likened to Holderness and its environs (Lillie and Chapman 2001; Lillie *et al* 2003; see Fig 8.1), with its range of similar landscape and environmental conditions (Dinnin and Lillie 1995a, 1995b; Taylor 1995; Lillie and Gearey 2000).

The Holderness region has the added advantage in that the archaeological and palaeoenvionmental remains were studied intensively and systematically as part of the English Heritage-funded Humber Wetlands Project. Consequently the environmental record is complemented by an archaeological record from fieldwalking and excavation (Head *et al* 1995a, 1995b; Chapman *et al* 2000), and previous interpretations of the distribution of some of this material (eg Head 1995).

Was environmental change perceptible?

In terms of the perception of landscape change, Coles touched upon the nature of landscape change in the North Sea Basin with the onset of sea-level rise.

> The variation in rate of rise, standstills, and oscillation, combined with local topography, mean that land loss probably occurred in fits and starts… At any given location, there may have been no perceptible change for decades or even centuries, followed by a catastrophic incursion of the sea over a distance measured in hundreds of metres or in kilometres (Coles 1998, 67).

Difficulties in understanding how such events might have occurred, and how they may have been perceived during the early Holocene, revolve around fundamental problems of landscape reconstruction, particularly in relation to the range of complex processes at work including eustacy, isostacy, and forebulge, in addition to erosion and accretion (Åkerlund 1996; Stouthamer 2001). Furthermore, rates of change alter through time; for example, in the Severn Estuary (UK) the rates of sea-level rise change from *c* 5–6mm per year from 10,000–7000 cal BP to *c* 2mm per year from 7000–5000 cal BP (Haslett *et al* 2001).

In addressing the problems of integrating environmental change with contemporaneous human perception of such change, it is necessary to consider the correct spatial resolution for modelling and analysis. Whilst it must be acknowledged that landscape and environmental change occurred on a very large macro-scale, approaches to understanding the perception of change can only be considered on the level of embodied experience, that is, the micro- and meso-scales (Merleau-Ponty 1962; Tilley 1994). Certainly, all spatial scales of analysis are required as it has been emphasised in the literature that prehistoric hunter-gatherer communities operated over landscapes rather than merely sites, and so consideration of the off-site landscape is crucial (Foley 1981; Green and Zvelebil 1993; Åkerlund 1996).

For the purposes of the current paper, the following section considers the concept of perceived change from the wider perspective of the landscape, that is, macro-scale level of analysis, in order to highlight the potential for creating analogous models against which an understanding of landscape change in the North Sea Basin can be evaluated.

A preliminary study of the Holderness landscape

We have already mentioned the appropriateness of the Holderness region to act as a proxy study

Figure 8.1 Location map showing the Holderness/Hull Valley region

area for the North Sea Basin, but this may only be useful if placed within a context that has the potential to provide insights into the changing nature and human perception of the consequences of inundation.

High-resolution sea-level data is difficult to determine, but a very generalised model of rates of change throughout the period from 7500 to 4000 cal BP (later Mesolithic to Bronze Age) has been provided by Long *et al* (1998). They have calculated that between these dates levels in the Humber region had changed from approximately −9m to 0m OD in relation to mean spring tide level—a mean rise of *c* 3.9mm per year. This figure reduced gradually to *c* 1mm per year after *c* 4000 cal BP. The earlier figure refers to the later Mesolithic, and consequently provides us with a linear basis from which to model inundation and to begin to assess its potential effect on contemporary populations.

By applying this formula to a digital terrain model of a section of central Holderness it is possible to predictively model rates of inundation (represented by surface water), assuming that the rate of rise is continual, as we might anticipate if this landscape change was occurring within the 'Doggerland' landscape in the earlier part of the Holocene (Fig 8.2). Consequently, for each ten-year period the total surface area of inundated land was calculated to provide an understanding of rates of change (albeit using a falsely linear rise in sea level).

The results from this preliminary study provided a graph of total increase (Fig 8.3), whereby very little change to the landscape is experienced for the initial *c* 100 years, but that following this, there is extremely rapid inundation of large areas of the landscape. In addition, there were times of significantly greater inundation whereby large areas were flooded in a very short period of time. This is an important observation as it represents the later Mesolithic, a period when, according to the available data, the rate of sea-level rise had already reduced.

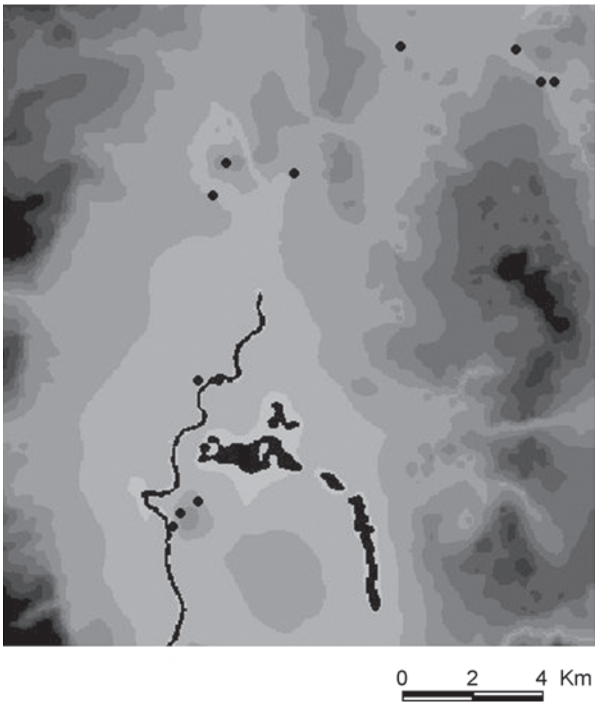

Figure 8.2 The Holderness terrain model forming the hypothetical study area, with darker shades representing higher topography (total vertical range of 5m). The dots represent the positions of late Mesolithic sites (after Head et al *1995a and b; Chapman* et al *2000). The black areas represent standing water within the landscape after 30 years of running the model, showing the infilling of an incised river channel and the development of ponds up to approximately 1m deep*

It should be remembered that Figures 8.2 and 8.3 use an assumed linear rate of sea-level rise. This modelling effectively 'smoothes out' sea-level rise across the duration of the modelling period. For brevity only one point in time is displayed in Figure 8.2 at the landscape level. Obviously in different topographical situations perceptions of land loss due to sea-level rise and the consequent inundation of the landscape will differ markedly. In areas of low relief much larger areas will become covered in water when compared to those areas where high relief occurs.

This is particularly significant at the Pleistocene/Holocene transition when the lowering of sea level due to ice cover in the Pleistocene had resulted in deeply incised river valleys. Until rising sea levels had resulted in the infilling of these river valleys the visible effect of sea-level rise would appear relatively minimal. However, once sea levels rose to the point where flooding moved beyond the confines of the river valleys, large areas of the landscape would 'suddenly' become inundated. In the Mesolithic period in the North Sea Basin, the point in time when rivers infilled and sea-level rise expanded beyond the confines of the river valleys would have impacted dramatically on individual perceptions of the landscape.

This study has effectively demonstrated that even in a scenario of consistent sea-level rise there will have been periods of minimal landscape change that might have remained unperceived by the contemporary population over a generation. However, these periods of low impact change may occasionally have been followed by periods of continual change, the extent of which could have been perceived by individuals within a lifetime, and certainly perceived within the communal memory. Furthermore, at certain times within this period of change there would have been episodes of extremely rapid inundation, perhaps over a single season, that would have altered the landscape considerably and perhaps irreversibly. The resolution of the dry land record may well prove invaluable in modelling such changes, not least due to the accessibility of the record, but also due to the fact that in certain instances the situation in areas such as Holderness may provide a more robust record than that preserved in the North Sea Basin.

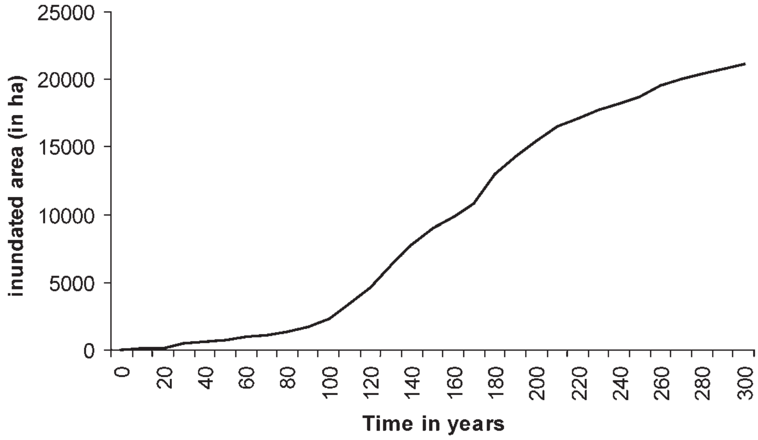

Figure 8.3 Graph showing increase in surface water over the 300-year study period

A question of scale

It has been suggested that prehistoric hunter-gatherers operated over landscapes rather than sites, emphasising the need to study the extra-site landscape (Foley 1981; Green and Zvelebil 1993, cited in Åkerlund 1996). Whilst this seems reasonable, particularly within the conceptual framework provided by Ingold's 'taskscape' (Ingold 1993), the relationship between the site and landscape (or micro-/meso-scale landscape) remains a useful parameter to consider in future analyses. Places where activities such as tool production were undertaken would have enabled a more 'static' appreciation of the environment. These 'sites', in addition to prominent or recognised natural features, form a frame of reference for 'mental maps' of the landscape, and thereby navigation through it (Gell 1985). Furthermore, these sites, and the routes or pathways that connect them, also provide a frame of reference against which environmental change may be identified or perceived. The hunter-gatherers of the North Sea Basin would have operated within a landscape that exhibited differing responses to sea-level change; the challenge for the future is to attempt to understand and model the nature of these changes. We suggest that Holderness provides an excellent opportunity to begin to develop our approaches to such studies.

This hypothetical investigation has demonstrated how extreme inundation events may be identified by their spatial scale. However, the perception of more subtle landscape changes by prehistoric populations may well have been possible due to a more intimate relationship with the landscape. Consequently, a more detailed survey of Holderness in relation to the distribution of known sites from this period (and indeed an assessment of their longevity) will be able to provide insights into past perceptions of more subtle environmental changes.

Conclusions

This paper has endeavoured to achieve two goals. Firstly it has argued that the Holderness region of East Yorkshire (UK) is an appropriate proxy study area for attempts to understand the cultural effects of inundation as experienced in the North Sea Basin. Secondly it has presented the results of a preliminary study of the effects of linear sea-level change upon a hypothetical landscape, quantitatively exploring the potential effects of inundation.

This study has not attempted an in-depth consideration of the many themes that will influence the cultural perception of landscape change. For example, vegetation will alter in response to changing hydrology (Godwin 1975). Furthermore, whilst the quantity of surface water was calculated, its effects were not considered in terms of its position. Clearly the location, width, and depth of standing water will influence the potential for movement through a landscape, and will also alter the cultural understanding of locales (Tilley 1994).

Despite these limitations, the overall hypothetical model of the analogous North Sea Basin situation begins to provide some answers to questions of perception, and also raises new questions. Further study integrating other environmental responses is required in order to examine such patterns more completely and thereby inform the modelling of potential patterns within the North Sea Plain itself.

9 Palaeozoological heritage from the bottom of the North Sea *by T van Kolfschoten and H van Essen*

Abstract

Since the fishing fleet was modernised in the 1950s, the amount of fossil material collected from the bottom of the North Sea increased considerably and thousands of fossil terrestrial mammalian remains have been collected. The southern part of the North Sea, in particular, is rich in fossils. Analyses of the fossil record indicated the occurrence of at least four faunal assemblages that differ in composition and age. The oldest assemblage (I) including *Anancus arvernensis* has an early Pleistocene, middle Villafranchian age. The second assemblage (II) is from the late early Pleistocene or early middle Pleistocene. The advanced — and probably typical — *Mammuthus meridionalis*, as well as specimens referred to *Mammuthus trogontherii*, are part of this association. Fauna association III with a late Pleistocene age is the best-represented group in the fossil faunal record from the North Sea. The huge collection represents the variety of species including *Palaeoloxodon antiquus* and *Mammuthus primigenius*. Faunal assemblage IV dates from the early Holocene. The radiocarbon ages, roughly between 9300 and 8000 BP, indicate that most of the Mesolithic bone and antler implements have a Preboreal or Boreal age.

The fossil record from the North Sea is enormous and is a rich source of considerable potential and scientific value. The North Sea faunal associations II, III, and IV date from a period when hominids were present in Europe, at least in the southern part. Hence, the zoological record from the bottom of the North Sea should be regarded as an integral part of our archaeological heritage — a major part, if we consider the amount of remains. The archaeozoological record deserves, therefore, full attention, while at the same time the new demands set by the Valletta (Malta) Convention must be taken into account. We have to stop the loss of data and initiate research that will contribute to our knowledge of Palaeolithic and Mesolithic human societies in north-western Europe including the North Sea Basin.

Introduction

Since historical times many towns along the coast of the North Sea and the former 'Zuiderzee' have had their own fishing fleets. The technique employed to catch flatfish is beam trawling, which dates from the Middle Ages when sailing boats with tiny gear fished the seabed in the coastal areas. Until the 1950s, most fishing boats had small engines and the fishing gear used was not heavy. With the replacement of the fishing fleet by much heavier modern vessels (Fig 9.1), more sophisticated fishing gear towed across the sea bottom exerts a higher pressure on the seabed. Since the fishing fleet was modernised, the amount of material collected from the seabed (in addition to fish!) has increased considerably. It includes much man-made debris and (sub-)fossil remains of mammals. Due to the large diameter (about 50mm) of the meshes of the nets, only the remains of larger mammals (Fig 9.2) are collected by the beam trawls; the occurrence of smaller mammal molars is largely restricted to sediments obtained from boreholes.

At a speed of five to seven knots, trawling across the seabed on average takes about one-and-a-half hours per haul, the track length varying between ten and thirteen km, and fishing mostly being carried out in loops. The penetration depth of a beam trawl into the seabed varies between 40 and about 80mm, depending on the composition of the seabed and the weight of the fishing gear used (Laban and Lindeboom 1990). Below a depth of up to 80mm, no deformation of the sedimentary structures is visible. Studies carried out by other institutes than NITG/TNO also indicated a penetration depth of about 70mm (Bridger 1970, 1972; De Groot 1973); during one of these studies, a video camera mounted on one of the trawls confirmed that the penetration was shallow. Thus, the collected fossil remains come from the upper 100mm of the seabed; part of these remains was exposed on the seabed and overgrown by marine invertebrates. The fossils are saturated by seawater. It is essential to desalt the bones before the impregnation with a solution of glue and acetone to prevent their disintegration.

Many thousands of fossils have been collected over the past 40 years and most of the material is stored in a large number of mainly small private collections. A relatively small number of fossils have found their way into the National Museum of Natural History, Leiden, the Netherlands, which houses the largest national collection. The most important private collections in the Netherlands are owned by D Mol (Hoofddorp), K Post (Urk) and H van Essen (Dieren). However, not all the fossils find their way into well-curated collections. Many fossils from the North Sea are sold all over Europe and exported to the USA and Japan. Due to the fact that vertebrate fossils from the North Sea are dispersed over many collections, the remains have never been studied systematically and described properly apart from some of the more spectacular finds. Another reason is the lack of detailed information about the stratigraphical provenance of the remains. Erdbrink (eg 1981, 1983b, 1983c, 1985) published a large number of fossil remains that mainly belong to large carnivores, and Hooijer (1984a,

Figure 9.1 Beam trawlers in the harbour of Stellendam (Delta area, province of South Holland, the Netherlands)

Figure 9.2 Fossils from the bottom of the North Sea collected by Mr P van Es, Stellendam, within a period of a few weeks

1984b, 1985) described some mammoth and ass remains from the North Sea. Van Essen and Mol (1996) and van Essen (2003) focused on proboscideans. More general reviews of the faunas from the North Sea have been published by Kortenbout van der Sluijs (1970–71, 1983), Drees (1986) and van Kolfschoten and van der Meulen (1986), Mol (1991), van Kolfschoten and Laban (1995), van Kolfschoten (2001) and Mol *et al* (2003).

Geographical and geological provenance of the fossils

The huge amount of fossils might give the impression that the entire bottom of the North Sea is covered with bones. This is, however, not the case. Detailed geological mapping of the North Sea (Cameron *et al* 1984, 1989a, 1989b) indicates that only specific formations (the Yarmouth Roads Formation, the Brown Bank Formation, and the Kreftenheye Formation) (Fig 9.3) yield fossil vertebrates and only in the areas where these formations outcrop would one find the fossils. The southern part of the North Sea has always been the richest in fossils, although some remains have been collected in the north-eastern North Sea (Post 1992). A map with locations where concentrations of mammalian fossils were found, based on unpublished data by J Mulder, was published by Drees (1986). The map shows that most of the mammalian remains were trawled in the southern part of the North Sea, in an area between the Brown Bank and the Deep Water Channel (52°30′–53°00′N/2°30′–3°00′E) (Fig 9.4). The area east of the Deep Water Channel is characterised by a series of north–south-oriented sand ridges. One of these ridges, the Brown Bank, forms the eastern margin of the area where most of the mammalian fossils have been collected. The western margin of the Brown Bank Formation is located at or close to the seabed east and north-east of the Deep Water Channel, and there are extensive outcrops of the Brown Bank Formation between the Holocene sand waves. These outcrops have yielded very large amounts of well-preserved late Pleistocene mammalian fossils.

Between the sand waves in the western part of the Flemish Bight sheet, that is, east of the Deep Water Channel, there are also outcrops of the early to middle Pleistocene Yarmouth Roads Formation, which have yielded a number of the mammalian fossils. Some of the fossil specimens probably originate from the IJmuiden Ground Formation, which is of Tiglian age and has small and scattered outcrops in the southern, and more extensive outcrops in the western, part of the

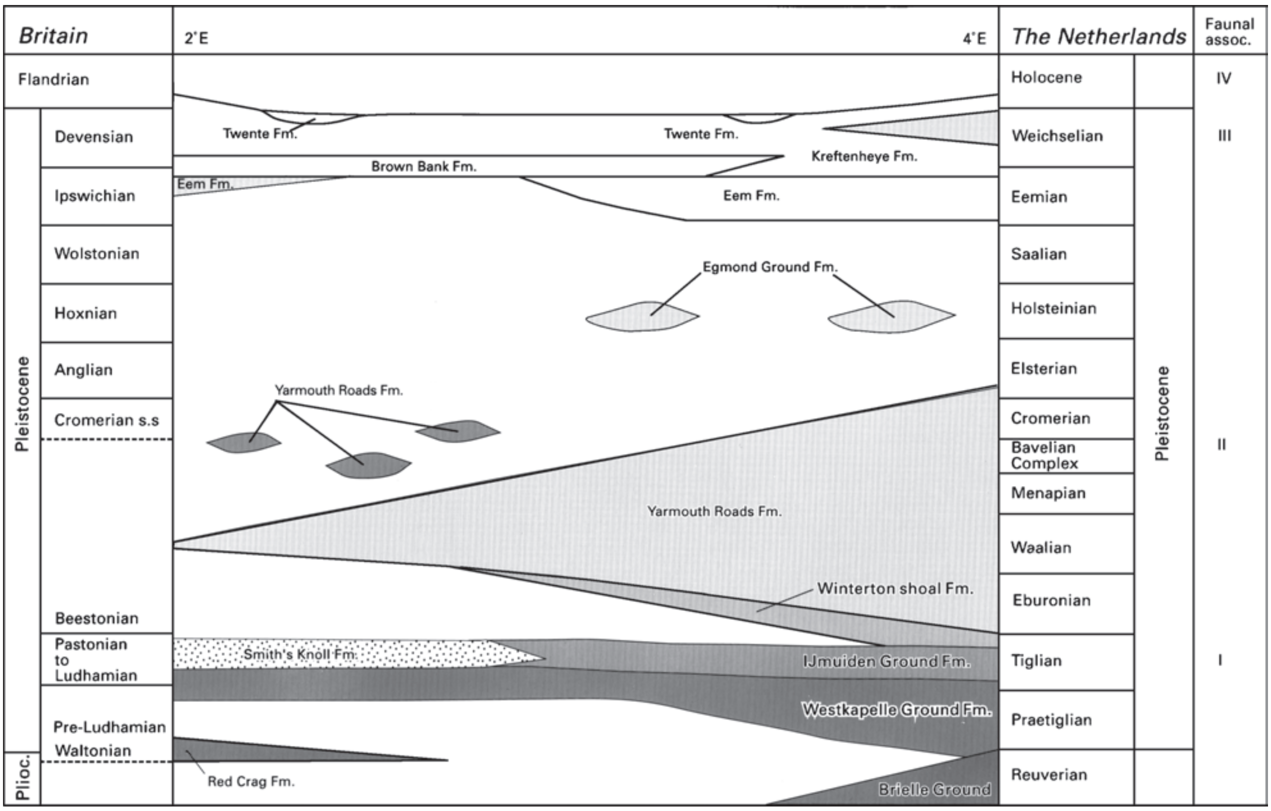

Figure 9.3 The suggested correlation of sedimentary formations with the Pleistocene and upper Pliocene stages of Britain and the Netherlands. To the right the four faunal associations found

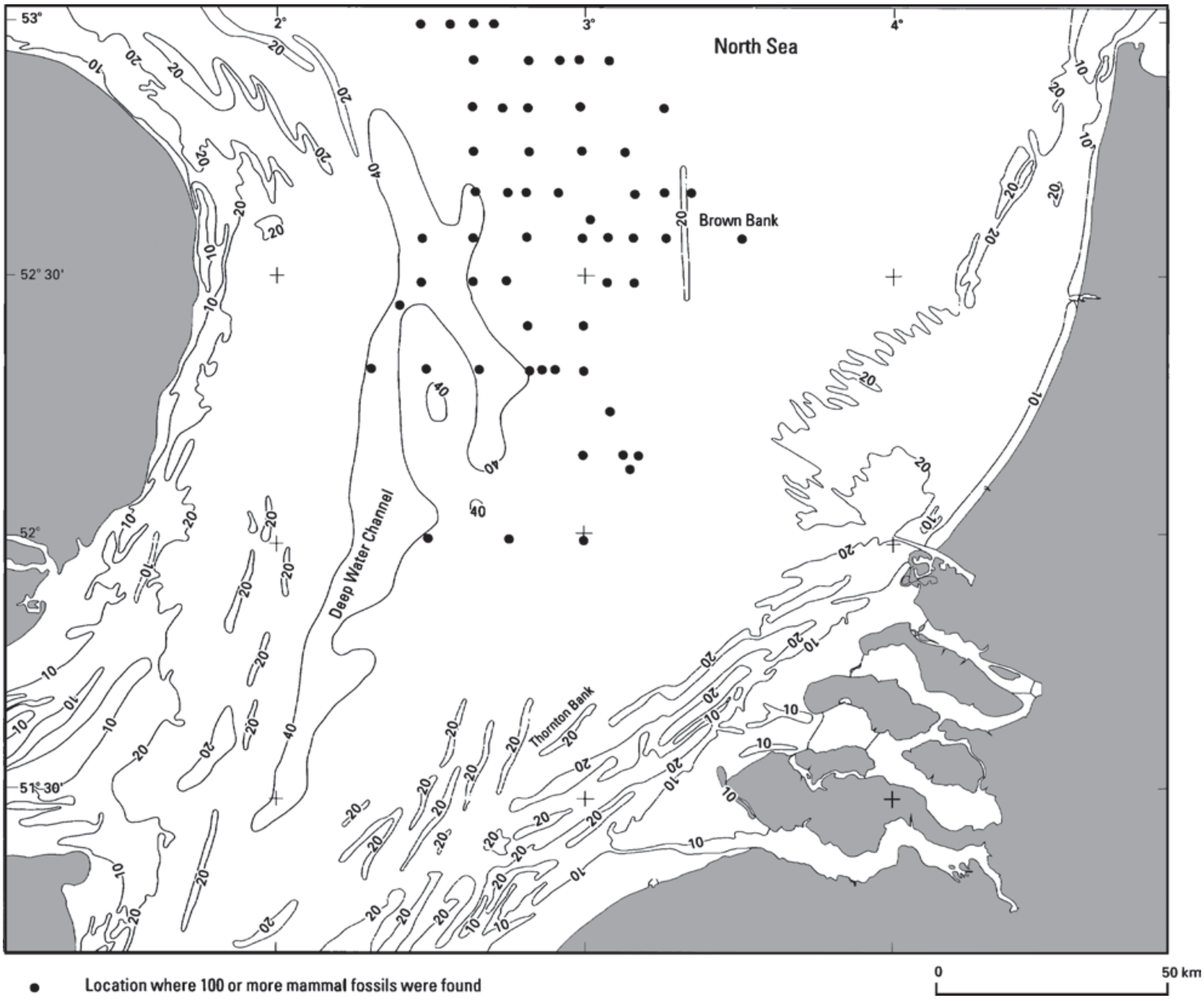

Figure 9.4 The area of investigation and the locations where concentrations of mammalian fossils were found. After Drees 1986 (based on unpublished data by J Mulder)

sand bank in the central part of this southern area of the North Sea. Reports about large amounts of fossils from the Dogger Bank, a huge sand bank in the central part of the North Sea, are unsubstantiated. The Dogger Bank is known to consist of reworked Pleistocene glacial deposits overlain by early Holocene tidal flat deposits (Jeffery *et al* 1988).

In the past few years, two new and limited areas rich in mammalian fossils were discovered. The first was revealed through dredging operations in the Euro Channel (52°00′N/3°30′E), the approach route to the harbour of Rotterdam. The fossils recovered from this area are known for their excellent state of preservation and very likely originate from the fluviatile Kreftenheye Formation (late Weichselian) that underlies the local Holocene deposits (Cameron *et al* 1984). The research in the Euro Channel is financially supported by the French enterprise CERPOLEX/ Mammuthus, as was the research in the other area, an elongate depression called ‘Het Gat’ (The Hole) (52°35′–52°50′N/3°20′–3°25′E). The fossiliferous part is adjacent to the eastern margin of the Brown Bank and yields remains attributed to fauna from the late early to early middle Pleistocene. These fossils presumably originate from the Yarmouth Roads Formation. Finds belonging to late Pleistocene faunas of Eemian and Weichselian age are much fewer in number (Mol *et al* 2003).

The mammals from the North Sea

The fossil mammals from the North Sea represent a number of faunal associations that differ in age, and the recorded species indicate different environments. The remains also show some variation in the degree of mineralisation. The specimens can roughly be divided into ‘old’, heavily mineralised, and ‘young’, less heavily mineralised remains. The oldest specimens recorded from the North Sea are not only heavily mineralised, but also dark-coloured. This phenomenon led to the adoption of the term ‘Black Bones Fauna’, often used in literature (eg Hooijer 1957) to refer to the oldest faunal association from the Schelde Estuary as well as to the oldest fauna from the North Sea, thus suggesting we are dealing with a single association. However, the dark-coloured fossils are now known to represent different faunal associations and to differ in colour as well. Arguments that the use of the term ‘Black Bones Fauna’ should be discontinued were advanced by Drees (1986), a view shared by the present authors.

The taxa represented in the faunal assemblage from the North Sea can be divided into two groups: a group which lived in a marine environment and a group of terrestrial mammals. A number of the marine mammalian remains, which are not further considered in this paper, have been described by Erdbrink (1972), Erdbrink and van Bree (1986, 1990), van Bree and Erdbrink (1987), and Post (1998). The oldest marine mammalian fossils may date from the late Pliocene or early Pleistocene, the younger ones from the late Pleistocene or Holocene. The terrestrial mammals from the North Sea are divided into four faunal associations (I–IV) (see van Kolfschoten and Laban 1995). The four associations can be regarded as groups of larger mammals with a comparable age, although their occurrence is not necessarily regarded as contemporaneous. In the fossil record from the North Sea, the late Pleistocene association (III) with *Mammuthus primigenius* is best-represented and best-known. The oldest heavily mineralised mammalian remains, formerly referred to as species of the so-called ‘Black Bones Fauna’, do not, however, represent a single faunal association. The list includes species which are restricted to the early and/or the middle Villafranchian, as well as species from the late Villafranchian/early Galerian. This indicates that we are dealing with at least two different age assemblages. The oldest association (I) is correlated with the Tiglian, whereas the younger one (II) is correlated with the later part of the early Pleistocene. A number of heavily mineralised specimens without diagnostic features are problematic and cannot readily be referred to either faunal association I or II.

Early Pleistocene terrestrial association I

Anancus arvernensis
Mammuthus meridionalis
Eucladoceros sp
Equus sp

Fossil remains from the species listed above come from an area close to the Thornton Bank in the south-eastern part of the North Sea, west of the Schelde Estuary. In this area, deposits of the IJmuiden Ground and the Winterton Shoal Formations occur, both with a fluviatile and a deltaic component. These early Pleistocene sediments are covered by late Pleistocene and Holocene formations. It is improbable that the specimens originate from the Thornton Bank itself, which consists of Holocene sand of the Bligh Bank Formation, overlying Eocene clay.

To date, only a single specimen of *Anancus arvernensis* has been described (Mol 1991; van Essen and Mol 1996). Several finds indicate the presence of the other species (Post, pers comm 2002; van Essen 2003). The occurrence of the early Villafranchian *Cervus perrieri* is mentioned by Hooijer (1984b). The heavily mineralised antler base shows close similarities with the lower part of the antler of *C. perrieri.* Since the specimen is too fragmentary to be certain of specific identification, it is omitted from the list.

Anancus arvernensis is known from faunas dated to both the early and middle Villafranchian (Azzaroli *et al* 1983), which include both the Reuverian and the Praetiglian (Torre *et al* 1992). The species is absent from the late Villafranchian fauna of Tegelen. An *Anancus* molar obtained from Tegelen-Maalbeek was dated to the early Eburonian III (Zagwijn 1963) and therefore supposed to be younger than the fauna from Tegelen. However, investigations of new exposures and material from the Tegelen-Maalbeek pit indicate that the molar was collected from deposits referred to as the Tiglian-B pollen zone which predate the Tiglian TC5 deposits that yielded the famous Tegelen fauna (Westerhoff *et al* 1998; van Kolfschoten 2001). *Mammuthus meridionalis* (Fig 9.5) is found in faunas which are dated to the middle and late Villafranchian and cover the early Pleistocene as well as the earlier part of the middle Pleistocene.

Both *Anancus arvernensis* and *Mammuthus meridionalis* (Fig 9.6) have also been found in the Schelde Estuary (mainly in the Oosterschelde). The heavily mineralised terrestrial fossils from the Oosterschelde are considered to be middle Villafranchian and hence slightly older than the late Villafranchian fauna from Tegelen, which is dated to the Tiglian TC5 (van Kolfschoten and van der Meulen 1986). The Tiglian terrestrial faunal association from the Schelde estuary has been correlated with the faunas from the Upper Shell Bed of the Norwich Crag (Thorpe/Norwich, Easton Bavents) and from the Campine, Belgium (Kunst 1937; van Kolfschoten and van der Meulen 1986). The more primitive, late Pliocene *M. rumanus* from the Red Crag Formation (East Anglia) (Lister and van Essen 2003) has, so far, not been indicated in the mammalian record from the North Sea. The absence supports the assumption that the assemblage including *A. arvernensis* has an early Pleistocene, middle Villafranchian age.

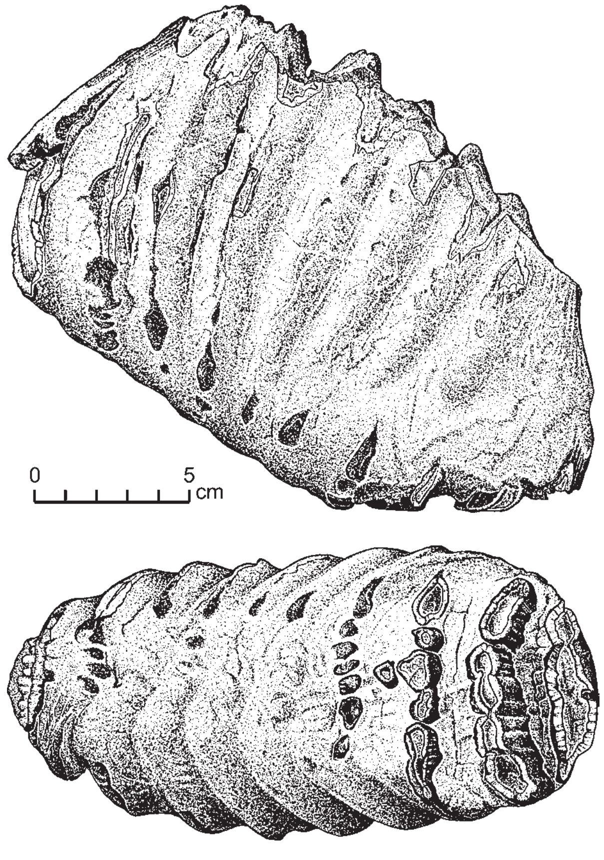

Figure 9.5 Mammuthus meridionalis*: M1 sin. (Coll HvE Dieren–333; drawing: HvE)*

Late early Pleistocene/early middle Pleistocene terrestrial association II

Trogontherium cuvieri
Homotherium cf *latidens*
Ursus etruscus
Mammuthus meridionalis (typical and advanced types)
Mammuthus trogontherii
Equus sp (the literature referred to *Equus* cf *robustus*, *E. bressanus*, *E. major, Equus* cf *stenonis*, *Equus* sp)
Stephanorhinus etruscus
Hippopotamus major
Sus sp
Alces latifrons
Megaloceros sp
Eucladoceros ctenoides
Cervidae gen. indet.
Bison cf *menneri*
cf *Praeovibus priscus*

Best represented in the mammalian record of the assemblage listed above are the remains of *Mammuthus meridionalis*. They are variable in size, plate number, hypsodonty, lamellar frequency, and thickness of the enamel. However, two types can be recognised: the more primitive one typical for *M. meridionalis* and a more advanced type. The comparatively primitive teeth are also mentioned above. Comparison with specimens from other European sites (van Essen 2003) showed that an average size increase of *M. meridionalis* teeth after the Tiglian is likely to have occurred in the North Sea area as well as elsewhere. The plate number increased slowly, so that M3 values are characterised by extensive range overlaps that, especially with regard to trawled finds, hamper the separation of evolutionary stages. The less voluminous teeth that develop before M3 show proportionally less change in this respect, so that M1 and the milk dentition could be argued to have remained in stasis during the early Pleistocene.

On the other hand, a narrowing trend caused the hypsodonty index to rise, so that it may be considered the better indicator of change where early Pleistocene mammoths are concerned. Lamellar frequency is influenced by the size of the tooth and its plate number. Its values must therefore be interpreted with caution, but the combination of large size and a relatively high lamellar frequency does constitute an advanced trait because these factors show an inverse relationship. Enamel thickness was found to be about the least distinctive feature in teeth

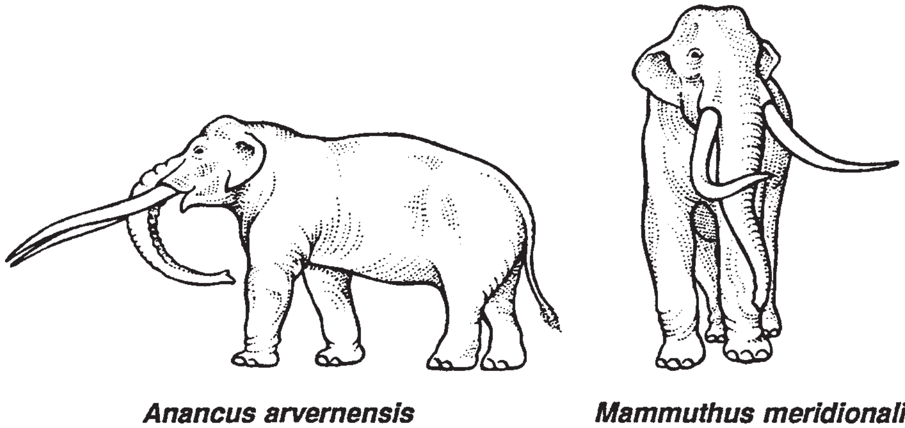

Figure 9.6 The Proboscidea of faunal association I from the North Sea. The figures are from Thenius (1962)

belonging to *M. meridionalis*, except for a Tiglian group of specimens that reached 5mm, a value not encountered in later populations.

On the basis of feature combinations, the *M. meridionalis* teeth from the North Sea are likely to represent all warm/temperate stages between about 1.8 and 1 Ma (million years ago) (Tiglian to Bavelian Stages). Morphology-based grouping, however, first of all leads to a division between those that cannot be told apart from the classic Italian material from the Valdarno Superiore (±1.8 Ma) and those that can, mainly by their hypsodonty index. The latter have so far been well outnumbered by the former. Recent analysis of the material referred to the subspecies *M. meridionalis depereti* (1982), housed in the Natural History Museum of Chartres (Fr), and suggested that this could be the normal situation (van Essen, in prep). The specimens are considered to have an age of about 1 Ma (eg Bonifay 1996) and are usually quoted as being advanced. Their M3 plate number, although including lower values, has generally shifted to 14 or 15. This is not beyond the upper end of the Valdarno range, whereas only a few specimens surpass the much older Italian ones in hypsodonty index. If this should be the general state of affairs among populations of about Bavelian age, the morphologically 'typical' teeth from the North Sea could be very variable in age (faunal associations I and II). Truly advanced ones would then remain numerically underrepresented, but would be the only reliable markers of a late early Pleistocene environment (faunal association II).

Apart from the advanced — and probably typical — *Mammuthus meridionalis*, faunal association II contains molar specimens referred to *M. trogontherii*. A fragment of a molar referred to *Mammuthus armeniacus* (= *M. trogontherii*) was described and figured by Hooijer (1984a). In addition, morphological data gathered by one of us (HvE) sufficed to positively identify a number of molars as belonging to *M. trogontherii* (see also van Essen and Mol 1996).

Both *M. meridionalis* and *M. trogontherii* are part of the mammoth lineage, which ends with *M. primigenius*. *M. meridionalis* is assumed to be the ancestor of *M. trogontherii* and the *meridionalis/trogontherii* boundary was dated at 0.7–0.6 Ma BP (Lister 1993). However, more recent discoveries indicate that *M. trogontherii* was present before the Brunhes/Matuyama boundary, ie before 0.78 Ma BP as indicated by the remains from Kärlich (Germany), whereas *M. meridionalis* is still present in middle Pleistocene faunas such as the one from Rio Pradella (Italy) and possibly the one from Voigtstedt (Germany) (van Essen 2003). This therefore indicates an overlap in the stratigraphical range of both species, which straddles the late early and early middle Pleistocene (Lister 1993; van Kolfschoten and Turner 1996).

Not only mammoth remains have been found. The faunal list also contains species as, for example, the extinct beaver *Trogontherium cuvieri*. A proximal part of a femur, trawled from the so-called Deep Water Channel, indicates the presence of this species (Mol *et al* 1998). Carnivore remains are rare. A humerus fragment identified as *Homotherium* cf *latidens* is known from the site Het Gat; the same locality yielded a fragment of a humerus that might be identified as *Ursus etruscus* (Mol *et al* 2003). The Perissodactyla in the North Sea assemblage are represented by a horse and a rhino. Heavily mineralised postcranial horse remains indicate their presence in the early assemblages. Hooijer (1984a) describes a very large calcaneum which is referred to *Equus bressanus* (= *Equus* cf *robustus* of Kortenbout van der Sluijs 1970–1971). The locality Het Gat yielded skeletal elements of a large horse that Mol *et al* (2003) assigned to *Equus major*. A number of fossils, for example a distal portion of a humerus of a rhinoceros that, in its dimensions, closely resembles the humeri referred to as *Stephanorhinus etruscus* (= *Dicerorhinus etruscus brachycephalus* as described by Guérin in 1980), indicate the presence of the rhinoceros (van Kolfschoten 1989b). The Artiodactyla are represented by several species: a hippopotamus *Hippopotamus antiquus* (= *Hippopotamus major*) (van Kolfschoten and Vervoort-Kerkhoff 1985; Mol *et al* 2003), a wild boar *Sus* sp (Identified by C Guérin) (van Essen and Mol 1996), and a number of cervids and bovids. Deer remains are the most frequently encountered fossils from the locality Het Gat (Mol *et al* 2003). They are identified as *Alces latifrons, Megaloceros* sp, and *Eucladoceros ctenoides* (van Kolfschoten and Laban 1995; Mol *et al* 2003). A large metacarpus and a number of postcranial bones from Het Gat are identified as *Bison* cf *menneri*. Mol (2003) describes three heavily mineralised vertebrae of *Praeovibus priscus*.

It is difficult to determine whether the North Sea faunal association II represents a single fauna or is composed of a number of species which did not live contemporaneously in the same environment. An argument in favour of the second option is the occurrence pattern of *Mammuthus meridionalis* and *Mammuthus trogontherii*. If the assumption is accepted that the two species, which have an overlap in their stratigraphical range, preferred different habitats (forest and steppe respectively), the conclusion is that the two species did not occur contemporaneously in the same environment. However, they might have roughly the same age and both date from the late early Pleistocene or early middle Pleistocene.

Faunal association II shows similarities with faunal association I from the Maasvlakte, an association with corresponding species such as: *Mammuthus meridionalis*, *Stephanorhinus etruscus*, *Hippopotamus antiquus*, and *Alces latifrons* (van Kolfschoten and Vervoort-Kerkhoff 1986; Vervoort-Kerkhoff and van Kolfschoten 1988). The Maasvlakte fossils, however, are not collected from *in situ* deposits and their stratigraphical position is uncertain. It is assumed, however, that the Maasvlakte I association most probably dates from the later part of the early Pleistocene or the earliest part of the middle Pleistocene because of the presence of *Mimomys savini* and the absence of *Microtus (Allophaiomys)*. Smaller mammal faunas with these characteristics date from the late Bavelian Complex as well as from the early Cromerian interglacials. Whether *Hippopotamus antiquus* occurred in north-west Europe during the Bavel Interglacial, the Leerdam Interglacial, and the early Cromerian Interglacials is not established. *Hippopotamus antiquus* is very well-represented in the fauna from Meiningen-Untermassfeld in Germany, and correlated with the Bavel Interglacial (Kahlke 1987). This indicates that at least some of the fossils from faunal association II from the North Sea may date from the late early Pleistocene and more precisely from the Bavel Interglacial.

To summarise, it can be stated that the faunal association II from the North Sea dates from a period to which faunas such as those from Bavel, Dorst, Oosterhout, Westerhoven, and Zuurland (at −27 to −37m NAP (Dutch Ordnance Datum)) belong. Most of the species listed above have also been recorded from the West Runton Freshwater Bed in East Anglia, which have an early middle Pleistocene age. However, other remains of these species, collected along the coast of East Anglia, are not accurately recorded. They may be older than the West Runton Freshwater Bed fauna. They may date from the stratigraphical gap between the Pastonian faunas correlated with the Tiglian (C5-6) and the early Cromerian faunas from West Runton (see Gibbard *et al* 1991).

Late Pleistocene terrestrial association III

Canis lupus
Crocuta crocuta
Panthera leo
Homotherium latidens
Ursus arctos
Ursus spelaeus
Palaeoloxodon antiquus
Mammuthus primigenius
Coelodonta antiquitatis
Equus caballus
Equus hydruntinus
Megaloceros giganteus
Rangifer tarandus
Cervus elaphus
Capreolus capreolus
Bison priscus
Ovibos moschatus
?*Sus scrofa*

Fauna association III with a late Pleistocene age is the best-represented group in the fossil faunal record from the North Sea. Thousands of late Pleistocene bones have been brought ashore. The huge collection represents the variety of species listed above (see also Mol *et al*, this volume; Glimmerveen *et al*, this volume). Large carnivores are well-represented in fauna association II. Erdbrink (1985) described cranial as well as postcranial material which belongs to larger members of the genus *Canis*, and because of their large size the specimens are referred to as *Canis lupus lupus*. They probably originate from early Weichselian deposits. However, an older date for the more heavily mineralised specimens, referred to as *Canis* cf *lupus* spp, cannot be excluded (Erdbrink 1985). A fragment of a mandibula of *Panthera leo* was referred to as *Panthera leo spelaea* (Erdbrink 1981), and there are also postcranial remains (Erdbrink 1983b and c). The cave hyaena, *Crocuta crocuta spelaea*, is represented by postcranial bones (Erdbrink 1983b, c, and d). Cranial as well as postcranial bear remains are known from the region just to the west of the Brown Bank; these remains are referred to as the brown bear, *Ursus arctos*, by Erdbrink (1967, 1982a, 1983b) because of their relatively small size in comparison with the dimensions of the cave bear *U. spelaeus*. The cave bear is also represented in collections from the North Sea (Erdbrink 1967, 1983b). The bear remains, according to Erdbrink, date from the late Pleistocene and the early Holocene. Recently, a mandible of *Homotherium latidens* has been recovered (Reumer *et al* 2003). The mandible has a radiocarbon age of about 28 Ka (thousand years ago) which is very remarkable because it was assumed that the species became extinct about 300 Ka ago. The absolute age of the mandible from the North Sea suggests that this assumption might be wrong despite the fact that the species has never been discovered in the large number of late Pleistocene fossil assemblages known from central and north-western Europe.

The Proboscidea are represented by two entirely different species: *Palaeoloxodon antiquus* and *Mammuthus primigenius*. Only a small number of molars and molar fragments referred to as *Palaeoloxodon antiquus* (Fig 9.7) have been collected from the bottom of the North Sea by Dutch and British fishermen. The remains most probably date from the Eemian or are associated with one of the warmer episodes of the early Weichselian. The woolly mammoth, *Mammuthus primigenius*, is much better represented. Thousands of remains of younger as well as older individuals have been collected to date. The molars generally show advanced characteristics, that is, they are high-crowned, have thin enamel, and a relatively high lamellar frequency, features which are indicative of late Glacial (Weichselian) remains. Their average M3 plate number, however, is lower than that

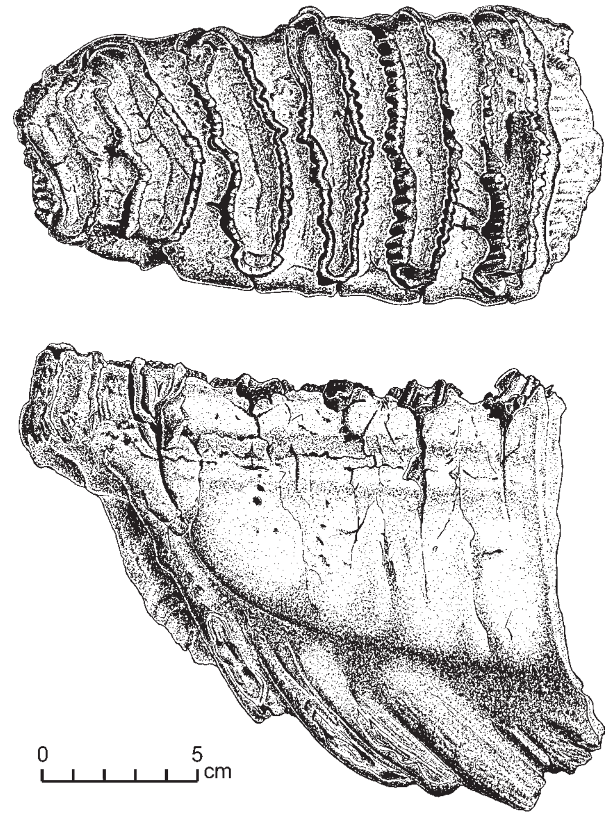

Figure 9.7 Palaeoloxodon antiquus*: M3 sin from the North Sea (Coll HvE, no 138; drawing: HvE)*

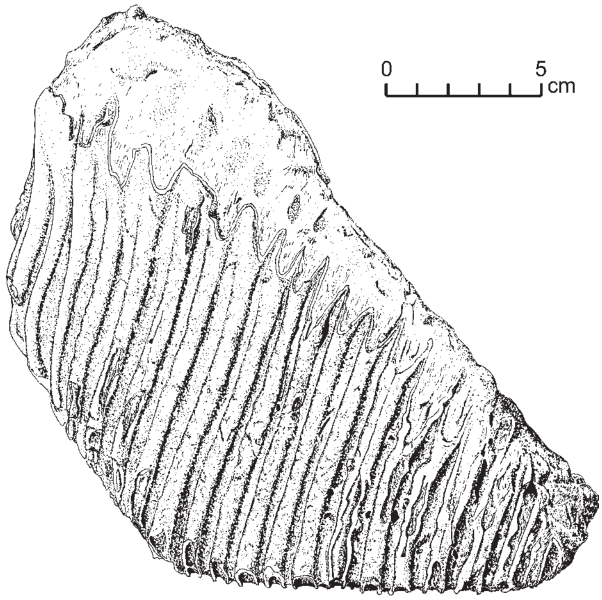

Figure 9.8 Mammuthus primigenius*, diminutive form: M3 dext from the North Sea (Coll HvE, no 109; see also van Essen 1986; drawing: HvE) (reconstructed max length 205mm)*

of contemporaneous specimens from Siberia (Lister and Sher 2001; van Essen, unpublished data). Some of the specimens are remarkably small (Fig 9.8). They represent mammoths of reduced size, the so-called diminutive forms. The characteristics and interpretation of such teeth are discussed by van Essen (1986; 2003). Radiocarbon dates on some diminutive specimens from the North Sea were provided by R D Guthrie, Fairbanks, Alaska. The values found are greater than 30 Ka BP and possibly indefinite.

The equid remains from the North Sea are identified as at least two species. Two very slender metapodials and a first phalanx are referred to *Equus hydruntinus* by Hooijer (1985), while a more robust specimen is referred to as *Equus caballus*. The *Equus caballus* material is, however, very variable in dimensions (Ligtermoet and Drees 1986) and most probably reflects the size reduction known to occur in caballoid horses since the late Pleistocene (Forsten 1993). Other species which inhabited north-western Europe during the last glaciation, such as *Coelodonta antiquitatis*, *Rangifer tarandus*, *Megaloceros giganteus*, and *Bison priscus*, are also well-represented in the fossil record from the North Sea. The musk ox *Ovibos moschatus*, however, is rare. Two metacarpals and the tip of a right horn-core of *Ovibos moschatus* were recovered from the bottom of the North Sea to the west of the Brown Bank (Erdbrink 1983a; Zijlstra 1991; Kerkhoff and Mol 1991; de Vries 1990).

Remains of the species listed above are also found in many sand and gravel pits along the rivers Rhine, Maas, Waal, and IJssel. The large majority of the fossils have been dredged up with sands and gravels of the Kreftenheye Formation. The late glacial faunal assemblages from rich localities such as Lathum/Rhederlaag on the River IJssel, east of Arnhem, are very similar in composition and possibly of a similar age. All the above species, with the exception of *Equus hydruntinus*, are also known from a large number of late Pleistocene localities in the British Isles (Stuart 1982).

Holocene terrestrial association IV

Castor fiber
Lutra lutra
Sus scrofa
Capreolus capreolus
Cervus elaphus
Alces alces
Bos primigenius
Homo sapiens

The rapid climatic amelioration during the early Holocene resulted in a rapid transgression of the North Sea. At the end of the Weichselian and during the early Holocene fresh water marshes developed in this area and a blanket of peat was formed. After about 8000 BP the Holocene sea-level rise drowned the area and tidal flats covered the entire southern North Sea.

Around 7000 BP the shorelines were more or less at the same position as they are nowadays (Verhart 1995). Hence, terrestrial mammals could only live in the area during the early Holocene, that is, before 8000 BP and before the introduction of domesticated animals into the area. This explains why the number of Holocene remains, as well as the variety of species, is restricted. Some of the early Holocene bones from the North Sea were used by people. Antler fragments of red deer and postcranial bones of, for example, aurochs were transformed into various implements such as shaft-hole picks, socket axes, and points (Louwe Kooijmans 1970–71; Erdbrink 1982b, 1991; Verhart 1995). The radiocarbon ages, roughly between 9300 and 8000 BP, indicate that most of the Mesolithic bone and antler implements have a Preboreal or Boreal age. Remains of domesticated animals such as cattle *Bos taurus,* pigs *Sus scrofa,* sheep *Ovis aries,* and goats *Capra hircus* are (sub)recent in age.

Conclusions

The four faunal associations from the southern part of the North Sea represent terrestrial faunas which inhabited the area between Great Britain and the European continent during different episodes of the Quaternary. The occurrence of fossils of terrestrial mammals (faunal association I) indicates that the area, or at least the southernmost part of it, was dry land during a phase of the Tiglian predating the Tiglian C5, to which the fauna from Tegelen is dated. The terrestrial mammal remains associated with the Bavelian Complex or the early Cromerian (faunal association II) indicate a second terrestrial phase. The third is referred to the late Eemian and Weichselian, whereas the last one (faunal association IV) is early Holocene in age.

It is obvious that the faunal assemblages described above do not reflect the entire mammal fauna. Not only are the smaller mammals lacking, but also the list of larger mammals is very incomplete. This is particularly the case with the oldest association (I) with only four species. There is little doubt that carnivores and bovids were also part of the fauna, but to date they have not been collected or recognised. (It is possible that recent finds indicate the presence of species that are not listed above. These finds have, however, not been published so far and are therefore not included in this overview.) Faunal association II is more diverse than I, but nevertheless is still considered incomplete. Most remarkable is the almost complete absence of large carnivores. Faunal association III, attributed to the late Glacial, is very similar in composition to late Glacial associations known from the continent. The North Sea associations seem to be a fairly good reflection of the entire larger mammal fauna which occurred in north-western Europe during the late Glacial. However, a number of larger mammals which also inhabited the Mammoth Steppe, the dominant late Glacial environment, such as the Saiga antelope *Saiga tatarica* and the Ibex *Capra ibex*, are lacking. They are recorded from mainland as well as British localities, but their remains are always rare.

The fossil record from the North Sea is enormous and is a rich source of considerable potential scientific value. It is obvious that the faunal remains date from different episodes of the Quaternary. The lack of exact stratigraphical information reduces to some extent the scientific value of the mammalian fossils, but not to a level whereby the material is solely of interest and value to collectors. If the fossil record is studied in detail and geological information is taken into account, much can be contributed to the knowledge of the faunal evolution in north-western Europe, more particularly the North Sea area during the Quaternary. Furthermore, the huge number of remains gives the opportunity to study individual variations. Dating of the material is, however, a problem. There are no reliable physical methods as yet to date the older remains associated with faunal associations I and II. For the interpretation and the stratigraphical correlation of these remains we have to rely on our existing knowledge of the Pleistocene fossil record and on the stratigraphical record of the southern part of the North Sea Basin, and combine our data with the results of conventional dating methods, for example, palynological analysis. Radiocarbon dating, applicable for remains referred to the late Pleistocene and Holocene faunal associations III and IV, is an accurate method for dating the latest assemblages. But what is the scientific value for archaeologists? Why should archaeologists care about these fossils?

Palaeolithic heritage

Sites on the continent as well as in Great Britain show that early hominids entered central and north-western Europe during the early middle Pleistocene and in southern Europe there are sites that suggest that hominids colonised the Mediterranean area during the late early Pleistocene. Hence, the North Sea faunal associations II, III, and IV date from a period when hominids were present in Europe, at least in the south. If we want to understand the environmental conditions in which hominids lived, if we want to have an idea about their habitat, we have to study the archaeological as well as the palaeoenvironmental data. The number of mid-Pleistocene (= late early and early middle Pleistocene) sites is restricted; the data from the North Sea are therefore valuable and contribute to the picture of the mid-Pleistocene environmental conditions and changes. Hence they are relevant for the debate on the Palaeolithic human colonisation of Europe, despite the fact that a direct relationship between the early hominids and the mid-Pleistocene mammals in the region is lacking. For the late Pleistocene and early Holocene we know that hominids were also present in north-western Europe. Bone artefacts and the presence of bones with cut marks show a direct human interference with the animal remains. The mid- and late Pleistocene as well as the early Holocene zoological record should therefore be regarded as an integral part of our archaeological heritage — a major part if we consider the amount of remains. The archaeozoological record deserves full attention, while at the same time new demands set by the Valletta (Malta) Convention must be taken into account. The present situation, in which the Palaeolithic and Mesolithic remains from the North Sea are mainly neglected by professional archaeologists and the fossils dispersed over a large number of (private) collections or commercially exported, is highly undesirable. This results in a huge loss of archaeological evidence and must be stopped. Politicians and managers responsible for our archaeological heritage have to take responsibility. They have to develop new strategies that will stop the loss of data and initiate research that will contribute to our knowledge of Palaeolithic and Mesolithic human societies in north-western Europe including the North Sea Basin.

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10 Biological proxy indicators in buried and submerged site prospection: what is significant?

by Peter Murphy

Abstract

Detection of archaeological sites deeply buried beneath Holocene sediments is problematic. In this paper the significance of biological proxy indicators (charred plant material and burnt bone) obtained from samples of palaeosols is evaluated. In this particular study, charred cereal remains and burnt bone were the best indicators of proximity of a Neolithic 'site'.

Introduction

Developing archaeological mitigation strategies for coastal and marine engineering projects, such as sea defence schemes and port developments, is dependent in part upon the ability to detect, or at least predict, the presence of prehistoric 'sites' on former land surfaces. (The word 'site' in lower case is used here to mean an artefact concentration, often associated with cut features, thought to indicate a focus of prehistoric activity.) The palaeotopography of land surfaces now sealed beneath the coastal sediment prism can be reconstructed using geotechnical and geophysical methods (Bates and Bates 2000; English Heritage 2003 and references therein). Similarly, reconstruction of submerged palaeotopography can be achieved by means of marine survey techniques such as swath bathymetry and sub-bottom profiling. Where sediment and palaeosol samples can be obtained, palynological and other palaeoecological analyses can be used to reconstruct vegetation change and any past anthropogenic impacts on natural vegetation. From these topographic and palaeoecological reconstructions, potential locations of sites may be suggested. However, to *demonstrate* the exact locations of buried and submerged sites unequivocally is more problematic, and this is an essential prerequisite for an effective mitigation strategy. There may be some potential for the application of magnetic susceptibility, but cultural indicators remain the best indication of a site. These may be artefacts or proxy biological macrofossil indicators.

Samples obtained from borehole cores, or by grab sampling from the seabed, can be submitted to conventional flotation and wet-sieving methods in order to retrieve macrofossils, such as charcoal fragments, other charred plant material including cereal remains and hazel (*Corylus avellana*) nutshells, and bone fragments. This general approach has been adopted in the Netherlands (eg Goudswaard 2000, 45) and is likely to be applied increasingly in the UK (Martin Bates, pers comm). However, observation and sampling of prehistoric land surfaces and palaeosols now exposed in the intertidal zone shows that burnt and charred materials are common, whether or not associated with artefacts and cut features (Wilkinson and Murphy 1995, 86–90). The mere *presence* of such material need not necessarily indicate the proximity of a site, for charred and burnt macrofossils were undoubtedly generated by non-domestic activities such as woodland clearance. The inter-site background levels of charred material are likely to represent an accumulation from activities which may have spanned thousands of years. Key points, therefore, are to assess what types of macrofossil are most informative, and to evaluate what absolute densities of material (g/kg or nos/kg of soil sample) are likely to indicate a site.

It is possible to address these points at intertidal sites where sediment cover has been stripped from large areas of the prehistoric land surface by erosion, and where systematic artefact collection, sample excavation, and soil sampling can be done. Results from such exposed sites can be used to aid interpretation of data from invisible sites which are still sealed by sediment or are submerged. An example is provided by The Stumble, Blackwater Estuary Site 28, Essex (TL 9014 0725: Wilkinson and Murphy 1995, 76–81 and in prep).

Methods

Full details of survey and excavation methods and results from The Stumble will be given in the final site report (Wilkinson and Murphy, in prep), and will only be summarised briefly here. The exposure was sub-divided into areas, differentiated alphabetically.

28J designated the main area of exposed palaeosol. Following surface gridded collection and plotting of artefacts, sample excavations were undertaken in a 20×20m grid pattern, over an area of 200×140m. Open-ended cylinders cut from an oil drum were used to define a fixed area for excavation at each grid intersection, whilst simultaneously excluding surface water. These 'sample bins' can be considered to be equivalent to the borehole cores that would be collected from an area of prehistoric land surface still sealed beneath sediment cover. A sample for flotation and wet-sieving was taken from each sample bin (J1–J88), except where the palaeosol had been truncated by erosion, or where thick deposits of estuarine sediments, probably indicating pre-existing or incised palaeochannels, were encountered.

Within 28J, excavation trenches were opened up in areas where surface artefact concentrations were recorded during survey. Soil samples were collected from 1m grid squares of the exposed palaeosol, and also from the fills of cut features underlying the palaeosol at 28A, B and E (contiguous trenches, which may be considered as one 'site'), and C, all of which produced predominantly early–mid Neolithic ceramics. In addition soil samples were taken from 28D (shallow pits with late Neolithic pottery) and Context 231, a burnt flint 'mound'. The minimum duration of activity is indicated by AMS dates on *Corylus* nutshell from 28C of 4780 ± 70 BP (OxA-2298, 3685–3385 cal BC, one sigma (68% confidence)) and on twigs from Context 231 of 3885 ± 70 BP (OxA-2297, 2490–2285 cal BC). Subsequently, intertidal sediments were deposited on the former Neolithic land surface, but recent erosion has resulted in almost complete loss of sediment cover. The relationship between the 28J sampling grid and the open area excavations is shown in Figure 10.1: not all of the latter were sampled, due to practical constraints.

Samples obtained were air-dried and weighed, then disaggregated in water. Charred plant material and other light components were separated by manual flotation, using a 0.5mm collecting mesh, and the non-floating residue was wet-sieved on a 0.5mm mesh. After drying, the flots were sorted under a binocular microscope at low power, extracting charred remains of cereals and flax (*Linum usitatissimum*) (comprising seeds, grains, spikelet forks and bases, glume bases, rachis internodes), hazel nutshell, seeds and stones of wild fruits, seeds and fruits of wild herbaceous plants, vegetative plant material (including root, rhizome, and stem fragments), charcoal and bone. The residues were sorted without magnification. Charcoal fragments >2mm were weighed on a digital laboratory balance.

The data obtained provide good information on the Neolithic plant economy, but here attention will be focused on just a few components: cereal remains (expressed as nos of charred cereal macrofossils/kg of air-dried soil), charcoal (g of charcoal fragments>2mm/kg of air-dried soil), hazel nutshell, endocarp fragments of *Prunus spinosa* (sloe), and bone fragments. For some sample groups, weights and densities of hazel nutshell (g/kg of air-dried soil) were determined, but in most cases quantities were so small as to invalidate weighing and density determination. Quantities of sloe endocarp and bone fragments were similarly very small in most samples. Consequently, for present purposes, abundance

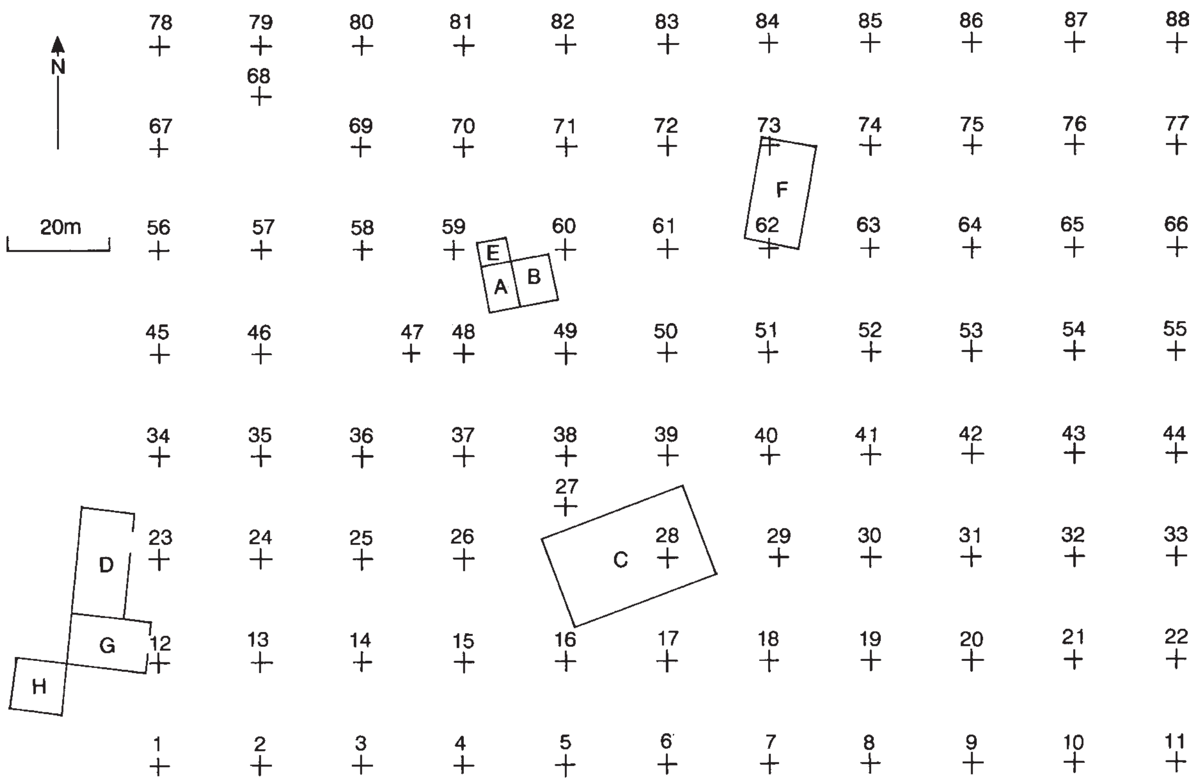

Figure 10.1 The Stumble, 28J. Locations of area excavations and sampling points

of these macrofossils is best considered mainly in terms of frequency and spatial distribution (*ie* nos of samples in which nutshell and bone occurred, and their locations across the exposed palaeosol).

Results and discussion

The results from the 28J sample grid are analogous to the data that might have been obtained had the site still retained a sediment cover, necessitating geoarchaeological prospecting by means of a grid of boreholes. There are gaps in the grid, for reasons explained above. Densities of charcoal, and the distribution of remains of cereals, hazel nutshell, sloe endocarp, and burnt bone in the surviving palaeosol are shown in Figures 10.2–10.4. All samples included some charcoal, but densities of >0.1g/kg of soil were very rarely recorded, and higher densities were not always in immediate proximity to the main sites. Remains of hazel and sloe were quite widely distributed, and showed little correlation with sites. However, cereal remains and burnt bone fragments were not found in samples more than 25m from sites. It is notable that a sample from the 28J grid, which lay within the open area excavation in 28C, did not stand out as exceptional, and the result, in isolation, would have given no indication that there was an artefact concentration and cut features there.

Charcoal densities for the 28J grid and for samples from excavated areas of the palaeosol are presented in more detail in Figure 10.5. This shows once more the very low density of charcoal in most samples from the palaeosol outside the main sites. It should be noted that a high proportion of samples from *within* the areas of open excavation likewise had very low charcoal densities. However, densities of >1.5g/kg of soil were recorded only in samples from the excavated areas, and only one sample from 28J, lying outside the excavated areas, included >0.5g/kg.

In Figure 10.6, densities of charred cereal remains are presented. Most samples from the 28J sample grid included no cereal remains, but most samples from the excavated areas contained at least some. An exceptionally high cereal density (for an English Neolithic site) of 95 macrofossils/kg of soil was recorded at 28A. There was, overall, good correlation between the presence of cereal remains and sites.

Frequencies of charred hazel nutshell are shown in Figure 10.7. From the 28J sample grid 39% of samples included nutshell, 88% of those from 28A, B, and E, and 95% of those from 28C.

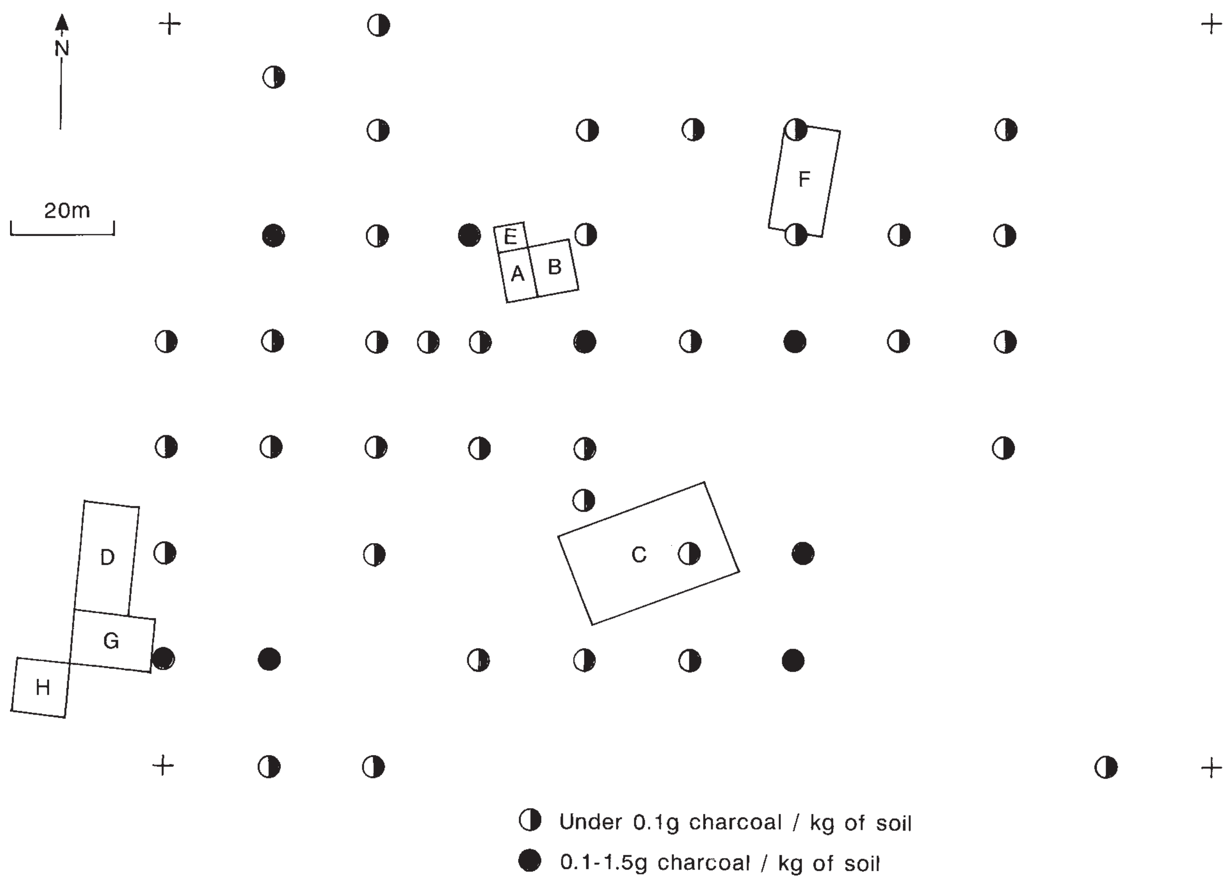

Figure 10.2 The Stumble. Charcoal densities across the 28J grid

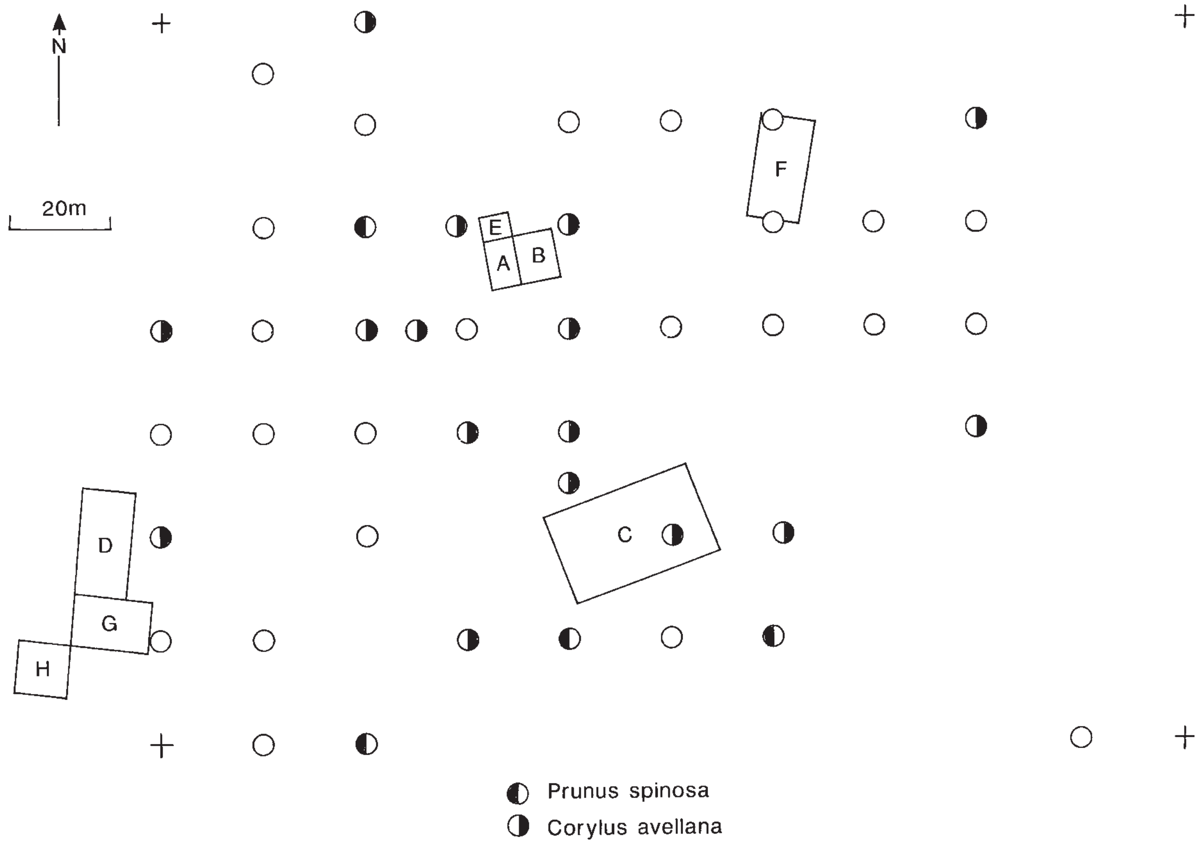

Figure 10.3 The Stumble. Distribution of Corylus avellana *(hazel) nutshell and* Prunus spinosa *(sloe) fruitstones across the 28J grid*

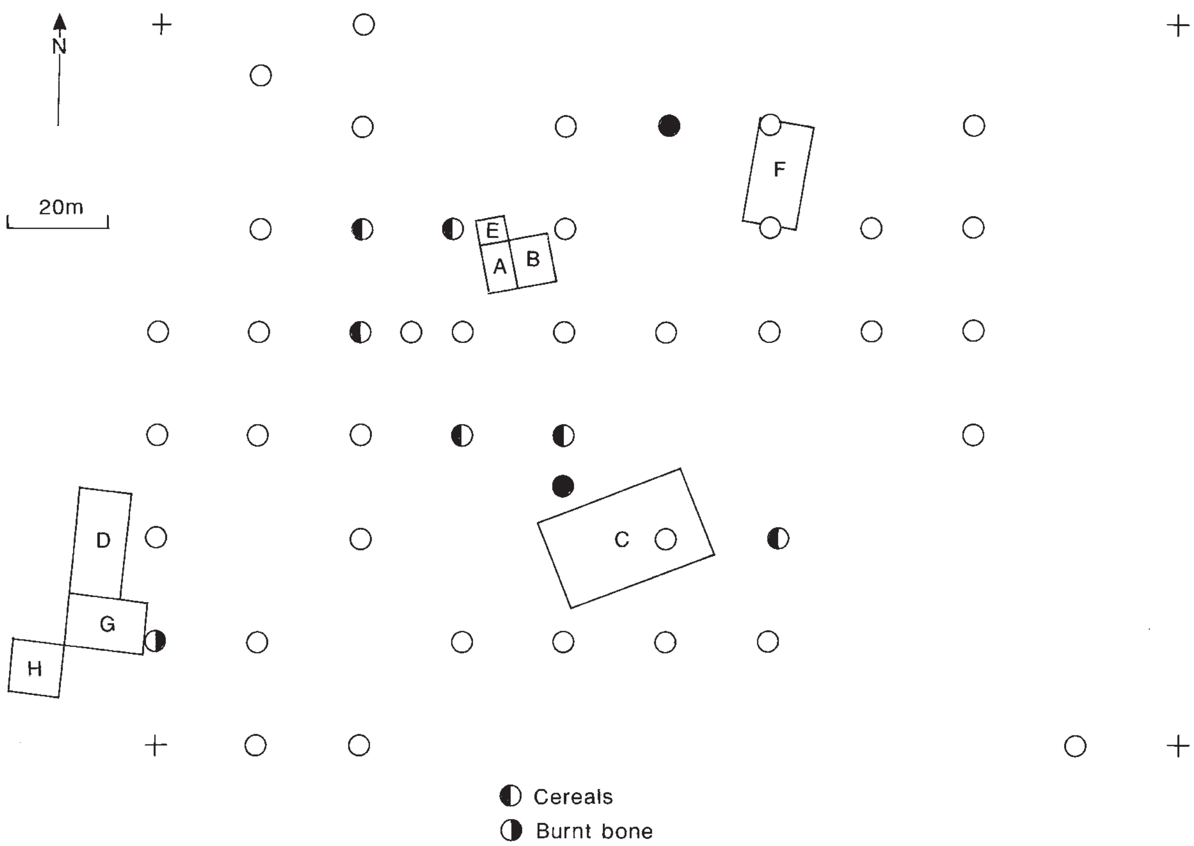

Figure 10.4 The Stumble. Distribution of charred cereal remains and burnt bone across the 28J grid

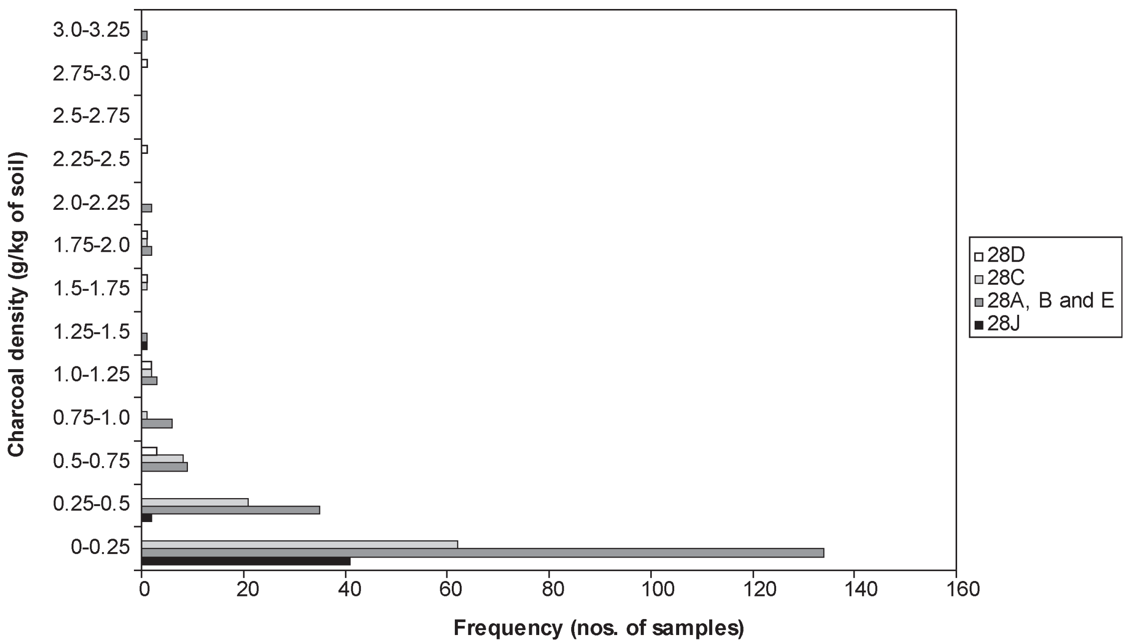

Figure 10.5 The Stumble. Charcoal densities

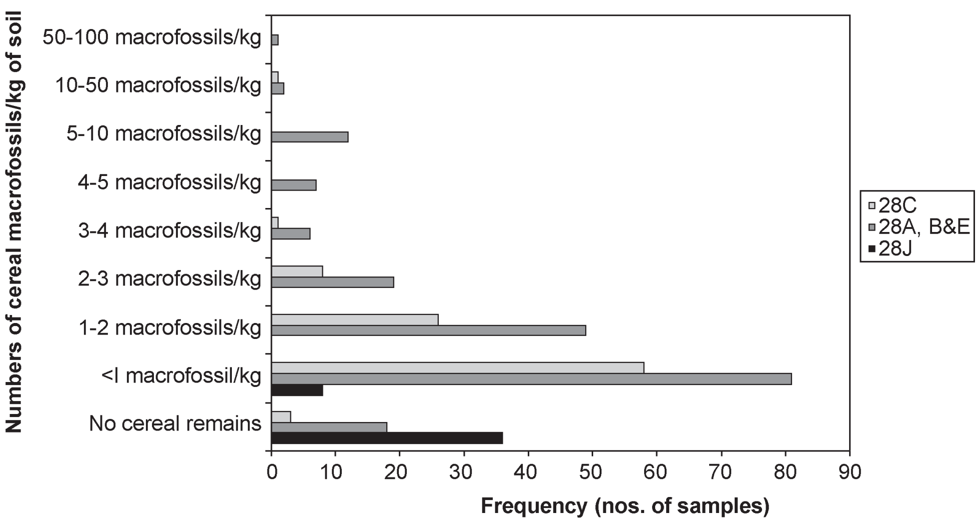

Figure 10.6 The Stumble. Densities of charred cereal remains

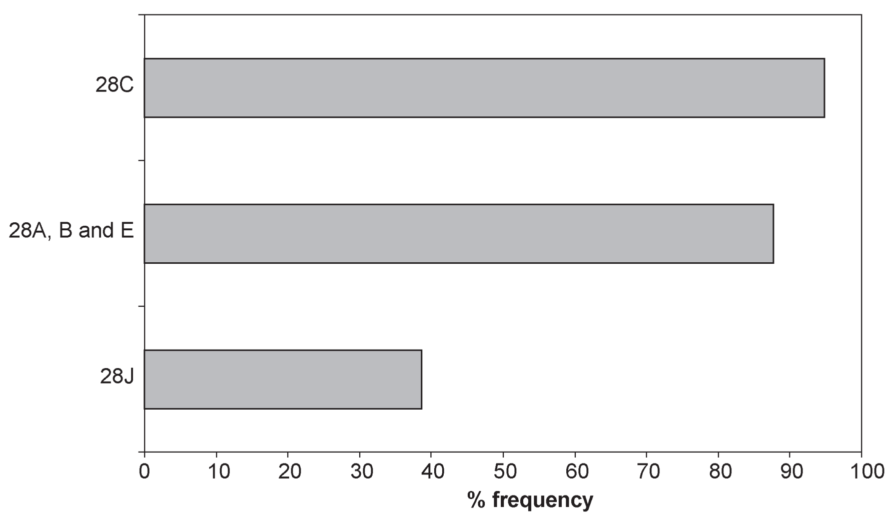

Figure 10.7 The Stumble. Frequencies of charred hazel nutshell

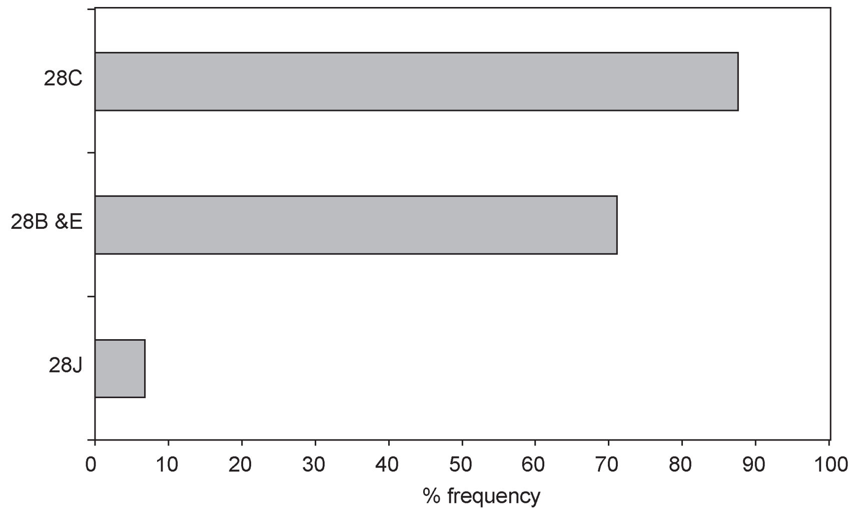

Figure 10.8 The Stumble. Frequencies of burnt bone fragments

Thus, in general terms, hazel nutshell was more frequent in samples associated with sites, but it was too frequent in outlying areas to be a reliable 'site' indicator.

Finally, in Figure 10.8, frequencies of burnt bone fragments are presented. There was a more marked difference between the 28J grid samples and those from 28B and E, and 28C: 7%, 72%, and 88% respectively.

Conclusions

In seeking to use these data to aid interpretation of palaeosol samples from buried and submerged sites it is important to emphasise that they relate to one particular site of one period — the Neolithic. Obviously, the results from this study must not be applied uncritically elsewhere and to sites of other periods. However, bearing in mind these *caveats*, the following conclusions may be drawn.

1 Charcoal was ubiquitous in the palaeosol at The Stumble, across the entire area exposed. Densities of >1.5g/kg of soil were recorded only from sites (areas of artefact concentrations and associated cut features) and with one exception samples including >0.5g/kg were also from sites.
2 Fragments of charred hazel nutshell and sloe fruitstone were widely distributed across the area investigated and their presence did not correlate well with sites.
3 Where charred cereal remains occurred, they were either within the main sites or no more than 25m from them.
4 Burnt bone fragments likewise correlated well with sites, and were not noted in samples more than 25m from them.

On this basis, cereal remains and burnt bone appear to be the best indicators of nearby Neolithic sites. Densities of more than 0.5g charcoal/kg of soil are likely to be significant, although dense charcoal deposits unrelated to settlement activity are known to occur elsewhere on the Essex coast (Wilkinson and Murphy 1995, 86–90). The presence of hazel nutshell and sloe fruitstone does not appear to be a helpful site indicator.

Section 4 Management and supporting data

Modern dredger working in the North Sea. (©: Thijs Maarleveld)

11 Prehistory in the North Sea: questions from development-led archaeology *by Antony Firth*

Summary

The present value of North Sea prehistory lies in the questions that it raises, rather than the questions that it answers. This paper outlines some of these questions by reference to a series of dichotomies arising generically from various studies undertaken within and bordering the North Sea. The dichotomies addressed are as follows:

Terrestrial or marine?	Is submarine prehistory simply an extension of terrestrial prehistory, or does it amount to a distinctive subject in its own right?
Nature or culture?	Is submarine prehistory essentially a branch of the natural sciences, or is it one of the humanities with a central focus on culture?
Sites or context?	Does submarine prehistory depend on the discovery of artefactual remains, or can it succeed using contextual data alone?
UK or North Sea?	Is the Continental Shelf of the UK an appropriate frame of reference for UK archaeologists, or should we address the submarine prehistory of the North Sea as a whole?

Notwithstanding some perceptions of the character of development-led archaeology, the need to address such questions in development-led archaeology is intrinsic to its success; academic dividend and commercial advantage are intimately related. Development-led archaeology has to engage with the wider academic, heritage management, and research-oriented community, but it is also important that this community engages with development-led archaeology. Perhaps the lasting value of North Sea submarine prehistory will be its erosion of boundaries in order to understand, appreciate, and conserve humanity's past.

Introduction

Our experience of carrying out archaeological investigations prompted by marine development is giving rise to a broad range of substantive questions about prehistory in the North Sea. Such questioning is intrinsic to development-led archaeology, as is the need to start formulating some answers. Clearly, it is important that development-led archaeology engages with the wider academic, heritage management and research-oriented community. But it is also important that this community engages with development-led archaeology.

Development-led archaeology is taken here to mean all forms of investigation — both in the field and desk-based — that are prompted by industrial construction or extraction activities. Key attributes of development-led archaeology, at least in the UK, are:

- That the location and objectives of archaeological endeavour are governed by the extent (footprint) and character of construction/extraction
- That the investigations are paid for by the developer, who is therefore a client with a clear interest in achieving value for time and money
- That there is a legally-binding contract between the client and the archaeologists carrying out the investigations
- That the methods and standards of investigation are regulated (by a curator) as an adjunct to the consent process that the construction/extraction must satisfy if it is to be permitted

Development-led archaeology is often thought of as private archaeology, though in many cases the developer is actually a public authority or other not-for-profit organisation. The need to demonstrate value for money in organisations answerable to electors or trustees is often no less intense than in those answerable to shareholders.

For the purposes of this paper, development-led archaeology is considered to refer only to investigations prompted by specific construction/extraction projects. There is an additional class of strategic archaeology prompted by more general industrial activity, such as strategic/regional environmental assessments.

Development-led archaeology can be contrasted with investigations that are prompted by other concerns, such as heritage management or research interests. While such investigations have their own often intense constraints, the hands of the archaeologists undertaking the work might not appear to be so clearly tied as those of development-led archaeologists. There is a perception that these ties — in objectives, cash, time, contract, and regulation — mean that the resulting archaeology is not what it might be. It appears to some observers that the pressures are such that the resulting investigations — and the archaeologists driven to undertake them — are blinkered, mechanistic and thoughtless.

If this were so, we would not be sufficiently informed, or aware, to advise our clients about the possible implications of their activities. This factor is especially true of marine archaeology in all its forms; our baseline data, the constraints of the working environment, and the limitations of available methods militate against the repeated application of stock procedures. Further, the character of our discipline as a human science means that our understanding of what might — or should — be achieved will be subject to endless revision. The dynamics of means and ends are pressing enough in the archaeology of ships and seafaring; looking towards the archaeology of prehistory based on seabed remains, we face a maelstrom. Development-led archaeology cannot skirt around the tempest by reliance on mechanical method. Rather, in this age of discovery, commercial pressures — our clients — demand that we press on, often in full sail. Recklessness is not a sustainable business option, so we are obliged to identify and qualify the risks to which we are exposing our clients, and to which we are exposing ourselves. All-in-all, this provides a strong incentive to careful thought; academic dividend and commercial advantage are intimately related (and see Andrews *et al* 2000, 526).

The commercial imperative

Wessex Archaeology is a fairly typical development-led archaeological organisation which has been undertaking coastal and marine development-led archaeology in the North Sea and elsewhere since the mid-1990s. The organisation is a charity but receives no core funding; all its income is derived from projects lasting from a few weeks to a few years. In some respects the lack of core funding adds to our financial security as there is no single sponsor capable of making a debilitating cut. Equally, the absence of dominant sponsors, the diversity of our portfolio, and the character of our relationships with clients are such that we can — indeed must — retain an independent voice. In UK archaeology, projects are distributed in a generally competitive milieu, hence we have to operate in a businesslike manner. We carry out development-led projects for both private and public clients, though private clients dominate in many marine industries. In addition to our development-led work, we undertake strategic projects; while public clients predominate in the strategic sector, some strategic studies are commissioned by private clients. A key point is that competition is not restricted to private clients and development-led projects; strategic projects and public clients have to be won in a competitive climate in which capability and value for money are judged in terms of a wider market place of potential suppliers.

In development-led contexts, our key deliverable is the investigation that we have carried out. The investigation — the conduct of field- or desk-based work, the resulting data, and the interpretations at which we arrive — is used to discharge some form of obligation placed on the client by the authority that regulates the process through which permission for development has to be obtained. A question uppermost in the client's thoughts is, therefore, does the investigation discharge the obligation to the satisfaction of the regulating authority?

The substance of an investigation is generally encapsulated in a report. These reports are prepared on behalf of the developers that fund them — though we usually retain intellectual property rights — and are commonly known as client reports. Generally, client reports are submitted to the client and their subsequent distribution rests with them. However, as the investigations have usually arisen through a consent process regulated by a curator, it is normal for the client to pass copies to the curator to demonstrate (hopefully) that the regulator's requirements are being met, and to inform subsequent discussions between the curator and developer regarding such further investigations as might be necessary. Having been passed to the curator, the reports should find their way into the archives attached to the curatorial authority's historic environment record (formerly known as Sites and Monuments Records (SMRs)), with the investigation itself being added to the record as an archaeological event. Historic environment records are open to the public, hence client reports can be consulted through the office of the curatorial authority. In some instances, client reports may be appended directly to the documentation accompanying an application for consent (for example, as a technical report attached to an Environmental Statement), and can be consulted by the public directly through the office where the application was deposited. Formal publication as a monograph or journal article is usually carried out following the completion of all investigations — including post-fieldwork analysis — that are associated with a development, if indeed the results are sufficiently important to warrant publication. While our organisation's history of formal publication is very good overall, many of the marine investigations that we are involved in are related to developments that are still in their early, preconstruction, stages. Consequently, our public output is so far limited to the client reports and documents accompanying applications that are referred to above.

As well as the substance of undertaking the required investigation, much of our work is advisory: advising the client on the overall process itself, exploring possible outcomes, and proposing options that anticipate situations before they arise.

In both substance and advice, clients depend heavily on their contractor having correctly and thoroughly understood the baseline of archaeological knowledge pertaining to the area being developed, and on the contractor drawing conclusions that are both satisfactory to the regulator and sufficiently robust to support the client's decisions. Again, the academic and the commercial quality of development-led archaeology are intertwined (see Firth 2000).

One consequence is that it is not possible to undertake development-led, seabed prehistoric archaeology without questioning what might be out there, what it might mean, and what ought to be done. Such questioning is not ancillary to the business; it is absolutely central to the survival of the organisation.

It is perhaps worth pointing out that even the big questions are central to the concerns of developers. Archaeology is pitted against some very big questions in both the developer's decisions as to how to proceed, and in the regulator's assessment as to whether the social or economic benefit of a development going ahead outweighs its scientific, cultural, and environmental impact. Both client and regulator can legitimately ask 'what is the value of submarine prehistory in the North Sea?' Archaeologists need not feel obliged to limit their response to such a big question to the particular; in my view, the present value of North Sea prehistory is the questions that it raises, rather than the questions that it answers. We do not yet know what we are going to find out, what it might mean to people, or what is worth conserving. Developer, and regulator, might reasonably demand that such an open-ended rationale be rigorous in its argument, but archaeologists can — with equal legitimacy — advocate a public interest case for proper regard to the marine historic environment irrespective of its ambiguities.

This then is the background to the questions that follow. Such questions arise from development-led archaeology not simply because we have had the opportunity to explore the prehistory of some specific sea areas; rather — as I have sought to show so far — raising such questions is intrinsic to development-led archaeology. The perspective is very much that of Wessex Archaeology, drawing from experience whose scope is determined by the pattern of development and which is, therefore, far from comprehensive.

Scope

We have carried out many projects that have implications for seabed prehistory at various locations around Britain and Ireland. The focus of this paper is, however, the results of investigations in areas within and bordering the North Sea (see Fig 11.1). While each investigation raises specific questions, the intention here is to consider the generic dichotomies and questions that arise from the various studies as a whole.

The development-led work referred to here is generally concerned with deeper water, that is, more than 10 m. Hence the focus is predominantly on early Mesolithic and earlier periods: the late Upper Palaeolithic and late Glacial in terms of preinundation surfaces, and lower, middle, and early Upper Palaeolithic in terms of buried surfaces, deposits, and derived artefacts. In UK sectors of the North Sea, well-provenanced archaeological evidence from these periods is rare. Certainly, there are many analogues for what might (should?) be in the deeper North Sea — internationally, in the Baltic, in intertidal and alluvial areas around the North Sea, and now at two UK inshore submerged sites — but there is still only a handful of finds that are immediately relevant to the developments we are asked to investigate (see Flemming 2002; Coles 1998; Bjerk 1995; Verhart 1995; and see Wenban-Smith 2002).

Terrestrial or marine?

Does the investigation of seabed remains tell us something different to land remains? This question is important in a practical sense because given the present limits of data about prehistoric material from the bed of the North Sea, we have to rely on an extension of land-derived data and interpretations by analogy to offshore areas. Working from the known to the unknown is clearly sensible and is perhaps the only reasonable way forward, but it presumes that the known we are working from is an accurate guide to the unknown. We must remain suspicious of this presumption. The vast areas now submerged would have been different to the uplands with which we are familiar, in terms at least of altitude and topography, and therefore also of the character of the land, its flora, fauna, and resource profile. Consequently, the ways in which these now-submerged lands were inhabited might have been quite different to the patterns of inhabitation that are evident on today's dry land.

One feature of the submerged lands that seems likely to have affected the activities and perhaps outlook of their inhabitants is the very low relief. Such low gradients over tens and hundreds of miles might even out the pathways across the expanse, or may actually concentrate activity on

Figure 11.1 List of sites

No.	Site Name	WA Reference
1	Area 466, North West Rough	51412
2	Areas 483 and 484, Humber	53591
3	Area 480 (106 East)	51524
4	Lynn and Inner Dowsing	51145
5	Area 254, Great Yarmouth	50482
6	Areas 446 and 447, Cutline	52357
7	Felixstowe South	53768
8	Bathside Bay	53824
9	Gunfleet Sands	51167
10	London Gateway	49572
11	Kentish Flats	51068
12	Princes Channel	54768

slight, highly localised topographic variations (see Barton *et al* 1995). Particularly distant horizons might have affected the ways in which habitual territories arose or were maintained, placing particular emphasis on key breaks-in-slope — such as our current coastline — as zones in which to exert, and demonstrate, influence. Such differences to terrestrial patterning may have been compounded by the dynamics of the submerging lowlands; changes attributable to rising sea level may have been gradual overall, but it seems likely that they were perceptible locally, at least for some periods. Take, for example, submerged forests; these must have stood at some time as swathes of dying trees (see Timpany 2002), impinging on the locals in their practical and perceptual engagement with their environment.

Currently we tend to rely on terrestrial data, and understandings based on terrestrial data, in seeking to address the unknowns of submerged prehistory. But few practitioners regard these submerged areas as simply more land. It is important to maintain the doubt; our understanding might be different if we started with submerged sites in their own context and in their own terms, and worked from the seabed back to the shore. It may even turn out that a seabed-based known proves a better guide to the unknowns of prehistory than what is currently known from land (see Fischer 1996).

Nature or culture?

A further key question is whether submarine prehistory is essentially a branch of the natural sciences, or whether it is a humanity with a central focus on culture. For the present, the relative absence of direct evidence of human activity from the North Sea is tending to encourage a reliance — at least in our work — on indirect indicators such as sea level, topography, and palaeoenvironment.

Correspondingly, much effort — far more than would be the case on land — is focused on the methods that are capable of generating data about these indicators, such as bathymetric and sub-bottom survey, coring, sampling, environmental analysis, scientific dating, and so on. Undoubtedly, these indicators framed the landscapes inhabited in prehistory, and these technologies and techniques are the most readily available means of quantifying their scope of action. However, there is a danger that in viewing prehistoric people through natural science data, we will fail to observe their humanity (see Firth 2002, 24–29).

The data upon which we presently rely draw attention to the massive natural processes that repeatedly shaped and inundated the seabed. But did people simply respond to the massive natural processes underway, or did they engage creatively with their environment? If they were simply responding, then we might get away with modelling on the basis of palaeo-topography and sea-level change. If there was creative engagement, however, then the shape of the land may be a misleading index of the distribution of prehistoric material on the seabed, or of its meaning. My inclination is that no matter how extreme the natural conditions, prehistoric peoples did not act as automata; the models that we develop to understand and predict the presence of surviving material in the North Sea will have to be informed by cultural considerations. It is the human scale that we must seek to comprehend: localised, detailed, and intimate. This is immediately apparent in the Scandinavian and Baltic evidence (see Grøn 2003; Grøn, this volume), but the perspective of deep-water archaeology in the North Sea — with so very few archaeological finds at present — is quite different.

Sites or context?

Acknowledging Rob Hosfield's point at a meeting at the Museum of London in April 2003, does submarine prehistory depend on the discovery of artefactual remains, or can it succeed using contextual data alone? Do we need to find artefacts in order to achieve a reasonable understanding of prehistoric life? As made clear above, our understanding of prehistory on the deeper seabed is, at present, based predominantly on context: deposits and surfaces, their architecture and formation, palaeoenvironmental indicators and postulated sea levels. Such context enables us to establish the scope and possibilities of human inhabitation, and is providing considerable insight. But how far can we take it? At some point we will have to proceed on the basis of direct evidence of human activity, to be archaeologists rather than palaeogeographers, which means that we have to find artefacts.

It is already clear that for all early prehistoric periods, submerged artefacts may be found individually or in groups in both secondary and tertiary contexts. Such artefacts may retain interpretable relationships with each other, with their matrix, and with other indicators. However, there is a danger that data acquisition, analysis, and interpretation might become focused on the processes that caused those contexts to be secondary and tertiary. Rather, we should seek to understand what, despite the convolutions of their journeys, such artefacts reveal about their makers (see eg Hosfield 2001).

Nonetheless, the discovery of primary contexts — sites if not monuments — in deep water is a prime objective. For development-led archaeology, the objective is really not to find them, but to circumscribe their likely presence in order that they can be avoided. However, success in demarcating areas of potential is unlikely to be entirely satisfactory in even the medium-term, despite meeting the overall policy aim of preservation *in situ* (English Heritage/RCHME 1996). Assumptions about potential — which again will rely on indirect indicators — will have to be tested in order that an overly cautious approach does not preclude large areas of seabed from reasonable exploitation. Some primary contexts will also be sacrificed to establish whether they can, in fact, reveal sufficient about our predecessors to warrant conservation. Having found primary contexts, decisions regarding preservation or investigation are likely to be driven economically as well as by academic or heritage management concerns: fieldwork and post-fieldwork are likely to prove very costly. Paradoxically, marine industry — which as the source of impact will be responsible for the cost of mitigation — may be the more cautious. Developers, and the archaeologists that represent them, may prefer to identify extensive but untested areas of potential, rather than having to deal with the possible expense of dealing with a small, but known, site.

At some point the scale will tip, and sites in deep water will not only be found but excavated. The likely gain in knowledge about the prehistoric peoples that inhabited the submerged lands is tremendous, given the possible densities of inorganic remains and the probable survival of organic artefacts and deposits. Perhaps the gain will create sufficient clarity to turn back to context as the principal means of gauging the presence and meaning of seabed prehistory. Though I suspect the case will often be made for excavating just one more. . .

UK or North Sea?

My final question is whether the Continental Shelf of the UK is an appropriate frame of reference for UK archaeologists. Can we hope to understand seabed prehistory by relying, as we traditionally do, on UK or English sources? Admittedly, this is the direction that we are coming from, basing our interpretations on the evidence of the nearest adjacent coastline. However, in some cases we have already sought a continental perspective, despite some difficulties. In particular, in addressing the prehistory of marine aggregate extraction areas in the eastern English Channel, close to the median line with France, it soon became apparent that the palaeo-coastline that we were constructing was that of mainland Europe, not of this island (Posford Haskoning 2003). Further more, the rivers within whose palaeo-valleys lay the targeted gravel rose to the south, hence we turned to the archaeology of their catchments in France, and to the archaeological records of the French authorities. Seeing this region as an embayment stretching round from Brittany to Cornwall, rather than as a channel, certainly undermines the notion of the present sea as a barrier between the early prehistory of Britain and its neighbours. It is surely more appropriate to see these lowland basins and their now-distant coastlines as the focus for human activity, with the uplands of our present countries being fringes that people explored as sea level rose. In this respect, the archaeology of the southern North Sea has to be approached transnationally, not simply as a means of gathering the relevant data, but because the arc of countries from Denmark to the UK form a single periphery to a now-submerged core that we wish to understand (Lewis, pers comm). In this paradigm, the broadening of scope to address the North Sea is not simply a manifestation of European archaeology. Rather, a North Sea-centred perspective is essential to understanding key questions in the prehistory of the UK and of England, as well as its neighbours (see eg Coles 1998; Raemakers 2003; Richards and Hedges 1999; Thomas 2003 on relations with the (North) sea in the Mesolithic-Neolithic transition, or Fischer 1996, cf Bjerk 1995; on the late Upper Palaeolithic colonisation of Scandinavia, or White and Schreve 2000 on Lower Palaeolithic population dynamics and technologies).

Conclusion

Development-led archaeology is not simply capable of raising questions: questioning is intrinsic to its business. The questions that are faced are not just those of logistics and cost; rather, development-led archaeology requires its practitioners to confront some of the biggest issues of interpretation — and of the relative value of archaeology within society — on a daily basis. Currently, the value of seabed prehistory is the questions that it raises. For the future it raises the possibility of an archaeology where the dichotomies dissolve, where disciplinary, political, and traditional boundaries in archaeology wither away. And ultimately, the value must lie in an understanding of our earliest predecessors within the landscapes that they inhabited, rather than within a framework of preconceptions that — for the present — we impose.

Acknowledgements

Responsibility for this paper and the views expressed must remain with me, though I would like to acknowledge my debt to many colleagues both in Wessex Archaeology and elsewhere with whom these matters have been discussed, debated, and argued. I am particularly obliged to the staff that have implemented Wessex Archaeology's marine and coastal projects over the years, to the clients who prompt, fund, and question our work, and to the vigilant curators.

12 Constructive conservation in England's waters *by Ian Oxley*

Abstract

This paper outlines the policy of English Heritage with respect to UK Territorial Waters and Continental Shelf. There is a particular concern to implement new legislation, and to ensure that palaeoenvironmental issues are integrated with submarine prehistoric archaeology, and the regulation of offshore industry.

Introduction

The passing of the National Heritage Act in May 2002 has corrected an anomaly in the way archaeology is managed in England and has given responsibility to English Heritage for maritime archaeology to the 12nm Territorial Limit. Many people will be familiar with high-profile wreck sites, but there is a growing awareness of the existence of, and impacts on, other aspects of the historic environment such as prehistoric sites and drowned landscapes (Oxley and O'Regan 2001).

To understand the whole submerged archaeological resource and to designate (ie to protect, manage, and promote) the most important sites poses a wide variety of challenges such as raising the awareness of other sea users and the wider community about the submerged historic environment and its potential.

In this paper I aim to:

- Summarise English Heritage functions
- Explain our new responsibilities under the new Act
- Describe our current policy to maritime archaeology
- Outline the major factors involved in implementing it.

New legislation, responsibilities, and challenges

In terms of their historical significance, their information potential, and their contribution to our cultural identity, it is clear that maritime archaeological sites should enjoy parity of esteem and treatment with their terrestrial counterparts.

The passing of the National Heritage Act 2002 extends English Heritage's remit by amending the definition of 'ancient monuments' in the National Heritage Act 1983 and the Ancient Monuments and Archaeological Areas Act 1979 to include sites in, on, or under the seabed (including those comprising the remains of vehicles, vessels, aircraft, or movable structures) within the seaward limits of the UK Territorial Waters adjacent to England. This extension in spatial responsibility amounts to approximately three-quarters as much again as the land area of England at a stroke.

English Heritage

English Heritage is a non-departmental public body established in 1983, sponsored by the Department of Culture, Media, and Sport. We have responsibility for all aspects of protecting and promoting the historic environment in England. English Heritage identifies buildings, monuments, and landscapes for protection and makes research available through publication. We aim to champion England's historic environment, focusing on the needs of future generations, the people of today, and those who are presently involved in change to that environment.

English Heritage's work

As the national archaeology service for England, English Heritage sets standards, promotes innovation, and provides detailed archaeological knowledge on the historic environment. This work includes the discovery and analysis of new sites, recording and researching the history of the landscape, and developing techniques for geophysical survey and technological analysis. Such survey results inform English Heritage's conservation and outreach initiatives, and those of our partners. In terms of structure English Heritage's front-line operations are run from a network of offices located in each of the Government's nine administrative regions. The aim of each regional office is to provide our public and professional customers with easy, one-stop access to a broad range of our services.

English Heritage's objectives

English Heritage seeks to unlock the potential of the historic environment through sustainable management of the best of the past, in partnership with national and local decision-makers. One of our key responsibilities is to develop and promote robust policies to aid those decision-makers.

We encourage central, regional, and local government to take proper account of the historic environment in their forward planning because the historic environment makes an enormous social and economic contribution to the lives and well-being of local communities. English Heritage works with many partners across the voluntary and private sectors to spread this message.

Drivers for change

In recent years there has been an increasing need to address the anomalous situation whereby the statutory advisor for the historic environment in England was unable to be involved in the submerged archaeological resource off our coasts. Due to the historical accident of setting the terrestrial limit as the boundary of 'England' when the organisation was set up, English Heritage was prevented from taking on responsibility for the English seabed. This is in contrast with our sister heritage agencies in Scotland, Wales, and Northern Ireland who have had such responsibilities for their marine zones for many years.

Taking to the Water

Prior to the National Heritage Act 2002 English Heritage published its initial policy on maritime archaeology, entitled *Taking to the Water* (Roberts and Trow 2002), which identified significant practical challenges. In particular, marine archaeological sites have the following characteristics:

- They cannot be easily accessed and managed without specialist skills, techniques, and equipment, and consequently, access to the resource is comparatively expensive
- They are situated in a hazardous environment, subject to continuous and sometimes rapid change
- In general terms they are poorly understood and, as a result, have poorly developed research frameworks
- They can be located outside the territory of their state of origin or beyond the territory of any nation state (ie in international waters), and can be unattributable to any single state (ie built, flagged, crewed, victualled, or cargoed by more than one country)
- The professional framework for maritime archaeology — in terms of survey, excavation, site management, and finds conservation expertise — is very poorly developed and supported, and amateur archaeologists have a more central role than they do in terrestrial archaeology
- The management of marine archaeological remains and the dispersal of portable antiquities take place within a wholly different legislative framework to that within which terrestrial remains and artefacts are managed.

Initial policy

As an initial policy *Taking to the Water*:

- Endorses the central role played by the National Monuments Record
- Through appropriate training and support, identifies the need to stimulate and support professional maritime archaeology
- Confirms the desirability of working closely with the amateur sector
- Identifies the need to engage with the recreational diving community and the non-diving public to instil an enthusiasm for the maritime historic environment and its conservation
- Makes broad proposals for a new legislative framework for England identifying the need for legislative change
- Through the involvement of local government archaeological ocers and the establishment and enhancement of locally based maritime Sites and Monuments Records proposes the promotion of greater local accountability in decision-making on maritime archaeology
- Describes the research priorities that will be accorded highest priority by English Heritage.

First steps

As a first priority to address the new responsibilities, English Heritage has undertaken to develop in-house expertise and this will be achieved in a number of ways:

- By continuing to maintain and enhance the maritime element of the National Monuments Record (to be referred to later) and ensuring its support by specialised staff
- By employing a maritime archaeologist to deal with all matters pertaining to the management of the maritime resource and to provide advice and support for our staff
- By extending training in maritime issues to regional English Heritage staff.

Curatorial advice

Almost 100 local authorities in England now have archaeological officers who provide curatorial advice based on local Sites and Monuments Registers.

The principal function of these archaeologists is to offer strategic planning and development control advice and there is a need to apply similar protection, policies, and resources to maritime archaeology. However, with the exception of certain limited stretches of enclosed waters, the powers of local authorities do not extend to the Territorial Sea and, in contrast to terrestrial sites therefore, the management of marine archaeological remains has generally not benefited from locally based, professional archaeological advice. Where local government archaeologists do engage with coastal and marine issues their involvement is characterised by responsibility without adequate planning powers or resources.

A few forward-looking coastal local authorities have already developed a maritime register capability, following the pioneering example set by the Isle of Wight Council, and others should be encouraged to follow their lead. A programme of maritime data exchange between local authorities and the National Monuments Record will also be given a high priority by English Heritage.

In order to enable the increased involvement of local authority archaeological officers in offering front-line advice on marine archaeology, English Heritage will offer to assist in the provision of training for local authority archaeological officers in subjects relating to the submerged historic environment, including procedures and techniques.

However, because of the specialist nature of this area of heritage management, this basic training to land-based archaeologists cannot be a substitute for the procurement of advice from an appropriately experienced practitioner. In the longer term, therefore, local authorities should give careful consideration to the means by which they could procure specialist advice in this field.

Designation review

In *The Historic Environment: A Force for our Future* the Government stated that it will examine marine archaeological legislation as part of a review of the case for integrating heritage controls. The process is underway and English Heritage is taking part by reviewing all the current designation mechanisms available for maritime archaeology. Both the Department of Culture, Media, and Sport and English Heritage hope to improve and refocus the way in which the whole of the historic environment receives statutory protection, including the maritime archaeological resource. However, that being said, there is little understanding of the character of the maritime archaeological resource, its distribution, its state of preservation, or the threats to its continued survival. Even amongst those submerged sites that have been located, only a fraction have been subjected to desk-based or field assessments of significance. Without access to this type of data, legislative protection and management strategies for the maritime resource remain primitive, and assessments of the importance of specific sites continue to rely on *ad hoc* judgements, rather than an understanding of their place within the wider archaeological resource.

Priorities

Finally to draw some of these issues together and to look at priorities for future actions in fulfilling our new responsibilities under the National Heritage Act 2002, we propose that any new management and protection regime for the maritime archaeological resource of England must:

- Have as wide a common basis with terrestrial legislation as possible, while recognising the special circumstances of the maritime historic environment
- Have regard to other coastal and maritime resource management interests
- Not be constrained by existing legislative devices
- Attempt to reconcile the mismatch between heritage and salvage procedures and law
- Cease to apply salvage law to known sites that are recognised as archaeologically important
- Make allowance for the provision of locally based professional archaeological advice
- Continue to encourage sea users to report wrecks from previously unknown sites to sustain the flow of information to the archaeological record
- Have regard to the full range of processes that are degrading the maritime historic environment, including seabed development
- Make provision for the emergency recording and active management of the maritime historic environment
- Retain powers that regulate diving on important wreck sites and permit these powers to be extended to other sites that are regarded as being of the utmost sensitivity and therefore vulnerable to unrestricted access
- Command the understanding and respect of the majority of responsible recreational divers and others with an interest in the sea
- Be enforceable.

Partnerships

To protect actively the maritime historic environment, to raise the standard of archaeological survey and recording, and to enhance public understanding and enjoyment are major undertakings that cannot be achieved by English Heritage alone, and the establishment of partnerships will be critical. We will maintain close links with the Department of Culture, Media, and Sport, but we will also foster good relations with all relevant government departments, agencies, and other organisations. We would hope to define and strengthen best practice arrangements by means of formal memoranda of understanding where appropriate.

We expect to engage with other legitimate users of the sea in a pragmatic and constructive way in the discharge of our duties pertaining to offshore consultations, and in the pursuit of our strategic aim to better understand and conserve the maritime historic environment.

Two examples of cooperation are:

1) British Marine Aggregates Producers Association/English Heritage guidance note, *Marine aggregates dredging and the historic environment: assessing, evaluating, mitigating, monitoring the archaeological effects of marine aggregate dredging* (BMAPA and English Heritage 2003).
2) Various Aggregates Levy Sustainability Fund projects to inform marine aggregates extraction industry and minimise disturbance. The advent of the ALSF coincided with the extension of English Heritage's responsibilities for maritime archaeology. This has allowed English Heritage to commission a range of projects that seek to improve our knowledge of a variety of subject areas including the archaeological potential of drowned landscapes. These projects are excellent examples of cooperation between academia, regulators and statutory advisors, and the archaeological contractor sector, for example, Palaeo-Arun Rivers project. The latter seeks to investigate the palaeoenvironmental and archaeological potential of submerged and buried landscapes off the south coast of England. These landscapes are poorly understood, and are at imminent risk from large-scale marine aggregates extraction. A strength of this proposal is that it builds on research carried out by the aggregates industry.

Conclusions

In the conservation world we must recognise that some change is necessary, but, in return there must be an understanding and recognition that the historic environment is a prime asset, with huge, unlocked potential.

At English Heritage we recognise that it is our task as an organisation to help landowners and legitimate users find sympathetic and economically acceptable strategies. Our new responsibilities present a major challenge to us of enhancing the wider community's knowledge, understanding, and appreciation of the maritime archaeology of England, including the submerged landscapes. An initial approach to the task has been described in this paper and we anticipate taking forward our strategy in partnership with other institutions and organisations with similar aims.

13 Existing resources of acoustic and sedimentary sample data for analysing the landscape for human occupation in the North Sea

by D Long, C Graham, and A Stevenson

Abstract

This paper describes a range of archived resources, core samples, bathymetric, and acoustic data which can substantially assist marine archaeologists studying the prehistory of the North Sea region. Some of the data and metadata are available online.

Introduction

A recent review of prehistoric evidence from the North Sea (Flemming 2002) shows that people lived in areas that are now submerged. The area of potential occupation in the North Sea is 434,000 square km (Fig 13.1), about the same as the combined onshore area of Denmark, Germany, and the Netherlands, or twice the land area of Great Britain. This is based on crudely calculating the area of land above 120m water depth, which marks the global lowstand during the last glacial maximum (*c* 18,000 years ago). However, as the area around the North Sea was subjected to glacial loading and the North Sea was probably uplifted due to the forebulge of that glacial loading, the geometry of the coastline will have differed from the contours we see today. Therefore such numbers and areas are very approximate, but they do indicate that there is an extensive area where people may have left evidence of their existence.

Searching the seabed for evidence of former human occupation is worse than the proverbial needle in the haystack. The sea prevents us from using the sense we use most on land — our eyes. We have to rely on a range of survey techniques to read the submerged landscape. Yet in order to improve the chances of finding evidence it is necessary to examine who has been surveying the seabed before us.

Collectors of data

At and near the seabed, extensive engineering data have been collected by the oil industry, which has been active in the North Sea since the late 1960s. Data include site surveys, high-resolution seismics, seabed sampling, and shallow boreholes collected for exploration wells. All these data types contribute to our understanding of the drowned landscape. In addition, data collected for environmental surveys may also be helpful.

Because of government regulation many of the data have been stored as part of licence agreements and are potentially available for assessing the palaeo-landscape. A wide range of data is accessible via industry metadatabases such as DEAL (www.ukdeal.co.uk).

However, this information is restricted to areas where hydrocarbon exploration has occurred, which are concentrated close to the median line down the axis of the North Sea and are rarely close to the modern coast. For nearer shore information, pipelines and cable route surveys (telecoms and power) are sources of high-resolution geophysical data, but often with widely spaced ground-truthing.

Another industry that collects large quantities of seabed information is the aggregates industry. It has exploited extensive sand and gravel off the south and east coasts of the UK with similar areas offshore of the Netherlands and Belgium. A range of surveys is conducted, including pre-licence evaluation, extraction planning, which can include very detailed surveys and, increasingly these days, post-extraction seabed surveys. There are a few other cases of offshore mineral exploration, including gold offshore of Helmsdale, Scotland and chromium offshore of Shetland, but none have been exploited. Their surveys may provide data for selected areas. Some coastal constructions require extensive surveys offshore. These include sewage outfalls and cooling water inlets for power stations, and the site engineering studies for wind farms. They can be useful sources of detailed surveys.

Hydrographic seabed surveys are the most widespread and can be extremely detailed, particularly in coastal areas, and are historically the most extensive. These initially were simple lead-line measurements of the water depth but increasingly included seabed samples and side-scan sonar to describe the texture and bedforms at the seabed. Nowadays areas are mapped with multibeam echosounders, and in areas where the sea floor is changing due to the migration of sand banks or the infilling of channels in approaches to harbours, this may be repeated very regularly. The fishing industry also produces maps that comment on the sea floor.

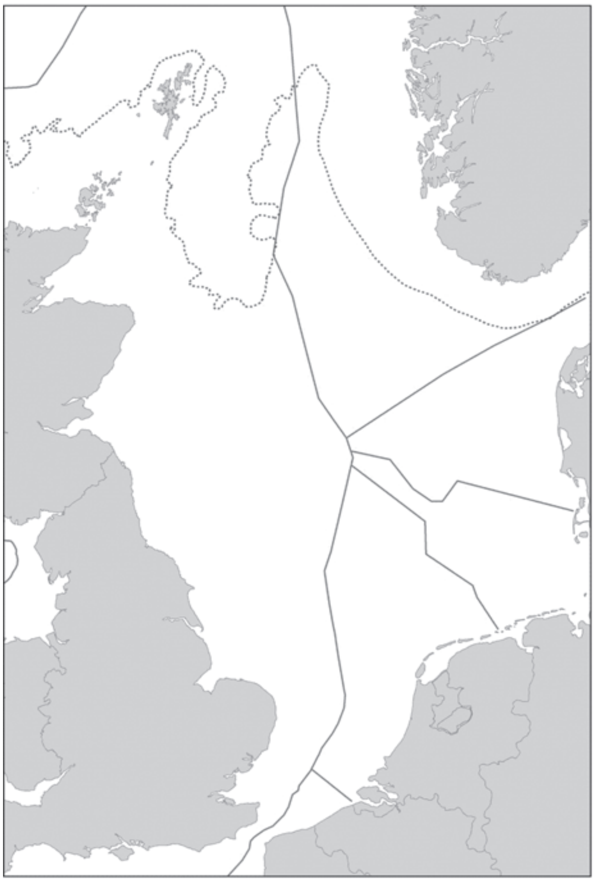

Figure 13.1 Map of the North Sea showing extent of shallow waters (<120m water depth – dashed line) that are potential areas for prehistoric human habitation

Scientific surveys are also extensive, covering all areas of the North Sea. These include bathymetry, geology, oceanography, environmental and habitat mapping. The most systematic mapping programmes have been undertaken by the geological surveys. Over the last ten to fifteen years these have become pan-European studies, often with EU funding, and this has ensured common systems, terminology, and methodology. Several universities have studied selected areas.

Data types

Profile data

Various energy sources are used to produce a range of frequencies. High frequencies give the best resolution but rarely penetrate beyond the top few metres. This can result in a few decimetres vertical resolution up to 10m below the seabed (eg boomer and chirp systems). Lower frequencies generated by airgun and sparker systems produce greater penetration (respectively 1km + and 200–300m) allowing depositional histories to be established, but with 10m resolution or less.

Sea-floor images

Seabed acoustic information has until recently been dominated by sidescan sonar. This is a reflection of sound either side of a vessel whilst it is moving, highlighting topography and lithological changes on the sea floor. Such surface data may be supplemented by visual observations, stills cameras and video, but these cover only a very small area. More recently, developments in bathymetric profiling have moved the echosounder to the forefront of site surveys with the development of multibeam echosounder mapping. This produces a swath of bathymetric data, often with a spatial resolution of 1m and a vertical resolution of decimetres. This resolution generates extremely large volumes of data and can be used in digital terrain models (DTM). In the future the backscatter record and interpretation will increasingly provide lithological information.

Other forms of geophysical data-gathering are limited but include resistivity and magnetic surveys. These are known to provide useful information in onshore geoarcheological surveys and are used to locate wrecks offshore. Even ground-penetrating radar, which is used onshore at many archaeological sites, has been tried offshore to locate wrecks in the Firth of Forth.

Ground-truthing

Data collected by geophysical means need to be interpreted and this requires samples for calibration. The simplest technique is using a grab to collect a sample of the seabed. It is important that the volume of the grab is known as this reflects how much mixing is possible. Small grabs such as Shipek Grabs penetrate about 50mm therefore giving an assessment of the surface sediments. However hydraulic grabs, often used in the aggregate industry, penetrate more than 0.5m into the seabed thereby potentially mixing a range of sediments. Greater penetration is obtained by cores. The simplest are gravity cores, a hollow tube forced into the seabed by a large weight on the end; depending on core diameter and stiffness of sediments, several metres penetration can be obtained. Piston corers may penetrate a little deeper. For greater penetration, a powered system is needed and vibrocorers, which vibrate a barrel into the sea floor, are commonly used offshore.

Interpretations of the data

As well as hydrographic and fishing industry maps, there are numerous maps of the sea floor of the North Sea published by the geological surveys of the surrounding countries. A common scale of

1:250,000 covering an area of 1° latitude by 2° longitude has been used for most published map sheets. For each there is (or is planned) a solid geology map, but it is the maps of the Quaternary deposits and seabed sediments that are most likely to be of value in landscape evaluation. Maps at broader scale covering the whole of the North Sea are planned, with a seabed sediments map being one of the first. In selected areas, finer scale maps exist but this usually depends on a particular study generating the base information. These are often in coastal areas.

Metadata

Information on the recovered data is increasingly available online and this allows an up-to-date assessment. Published maps, even from the early 1990s, may contain only a quarter of the currently available information. The oil industry metadatabase DEAL (see above) has information on data collected mainly as part of hydrocarbon exploration and is too deep to be of relevance to evaluating the former landscape of the North Sea. However there is some information on, and links to, site investigations and environmental surveys.

Within the UK, much data is held on the BGS geoscience database www.bgs.ac.uk/geoindex. It gives location and data information for both sample and seismic data sets. For Europe-wide information, the web site www.eu-seased.net contains information on 300,000 sample locations. This includes samples collected by national geological surveys, academic institutions, and industry. The site provides information on the types of seabed samples and cores taken, and where to go for further information. A similar metadatabase is now being compiled for information from geophysical surveys covering shallow seismic data and sonar imagery. This database is expected to hold metadata for over 2.5 million line kilometres of survey tracks.

Material for inspection

Having located information, when reading any core description it is important to bear in mind the purpose for which it was collected. Words used for engineering purposes differ in meaning from that familiar to geologists, let alone that understood by someone considering the former landscape in terms of human occupancy. It is sometimes possible to re-examine cores. In contrast to the high cost involved in collecting cores from the seabed, the costs of sample storage are modest, thereby encouraging samples to be stored for a long time. Unfortunately, samples from the sea floor begin to alter as soon as they are collected, changing their physical and chemical properties, and core materials are vulnerable to biological attack. These changes can be restricted if the cores are stored at low temperature and this should be borne in mind when examining material.

Conclusion

The submerged landscape of the North Sea is an extensive area that prehistoric people inhabited. To maximise the value of future studies, existing surveys from academic and commercial origins should be examined. The increasing amount of data that is available online allows this to be a rapid and worthwhile first step. High-resolution swath bathymetry and sidescan sonar, in particular, for the first time offer the possibility of identifying human influences on the offshore landscape. Interpretation of this information should be made utilising the experiences of archaeologists together with marine geologists and other scientists who have collected data in the North Sea.

Acknowledgement

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14 Can we manage?

by Thijs J Maarleveld and Hans Peeters

Abstract

Information on the deposition of prehistoric material in the underwater environment of the North Sea and elsewhere is combined with the challenges of present-day sea-use and development that curators with a brief to assess and mitigate their effects are facing. Due to the development of shallow seas like the North Sea prehistoric remains are part and parcel of maritime heritage. In order to assess their presence and importance some crude approaches and predictive tools have been developed. These indicate a way forward for large-scale concentrated projects like the port extension for Rotterdam. With regard to other, more dispersed, activities like the exploitation of oil-fields the predictive tools cursorily presented here inform our understanding. They may help to formulate research to be undertaken in compensation if mitigation is not realistic. To the background of such reasoning, the authors posit that indeed we can manage. Maritime heritage management may have its specific problems and approaches, but it does produce important results and more and better is to be expected.

Introduction

The development of regulations for the protection of archaeological heritage has seen important steps in the last decade or so. These regulations include underwater heritage which also includes early prehistory. The issue to be dealt with in this contribution is the question of whether we can manage this archaeological resource given our present level of understanding and given those regulations. Both our understanding and the regulations do, of course, pose specific problems and this applies both to the management of heritage from the early past and to the management of heritage concealed by the North Sea. Nevertheless the answer is positive. We can start to influence the way in which archaeological information and heritage are treated and taken into account in decision-making regarding the North Sea. That is what heritage management at the most basic level is all about.

Much of the archaeological information is produced as a corollary of other activities. Some of these are slightly destructive. Others are more massively so. Fishing, for instance, is practised mostly with ground-tackle in the shallow southern North Sea. This affects the bottom-surface in a way that is comparable to deep ploughing on land and does so with tremendous intensity. Like ploughing and field-walking the process occasionally produces archaeological information. Whenever this occurs the context has already been disturbed. The same holds true for occasional finds during the process of laying pipes or cables, not to mention the intensifying extraction of aggregates, gravel, and sand. It is quite evident that creating possibilities for research prior to, or upon, disturbance is the preferable option as compared to concentrating on disturbed contexts alone. Often it is simply impossible to do so, but we can influence what happens if at least we understand what we want and know in what direction we want chance, discovery, serendipity to take us. If those conditions are met, a lot more can be done than one would suspect. Some developments are beyond control, but many are not. Like consideration and care for the environment, consideration and management of archaeological heritage has become a fully acceptable aspect in decision-making in spatial planning. This does not necessarily mean that it is really being catered for in the best possible way. It does, however, mean that archaeologists and heritage managers have a responsibility to try and improve their impact. Heritage from early prehistory may not seem to be the easiest heritage to manage in that way, but that is no reason not to try.

In this contribution we present some of the approaches chosen by the National Service for Archaeological Heritage (ROB) in the Netherlands. We discuss some predictive work, both for the underwater area and for submerged subsidence areas that have recently been reclaimed as (sub-sea level) land. Our conclusion is that important deposits containing archaeological evidence have been preserved in sealed conditions at specific locales in the North Sea as well as deeply buried under Holocene sediments within the confines of the present-day coastline. We will touch upon some lessons learned that may be relevant for both areas and we will present our approach with regard to the seaward development of the port of Rotterdam. The main areas discussed in this text are shown in Figure 14.1.

Although for various reasons underwater archaeology in the Netherlands was late to develop (Maarleveld 1997), it has now become integrated into the organisation of heritage management. The National Service for Archaeological Heritage contains a Division of Maritime Heritage. It is responsible for the management of archaeology hidden beneath the larger national bodies of

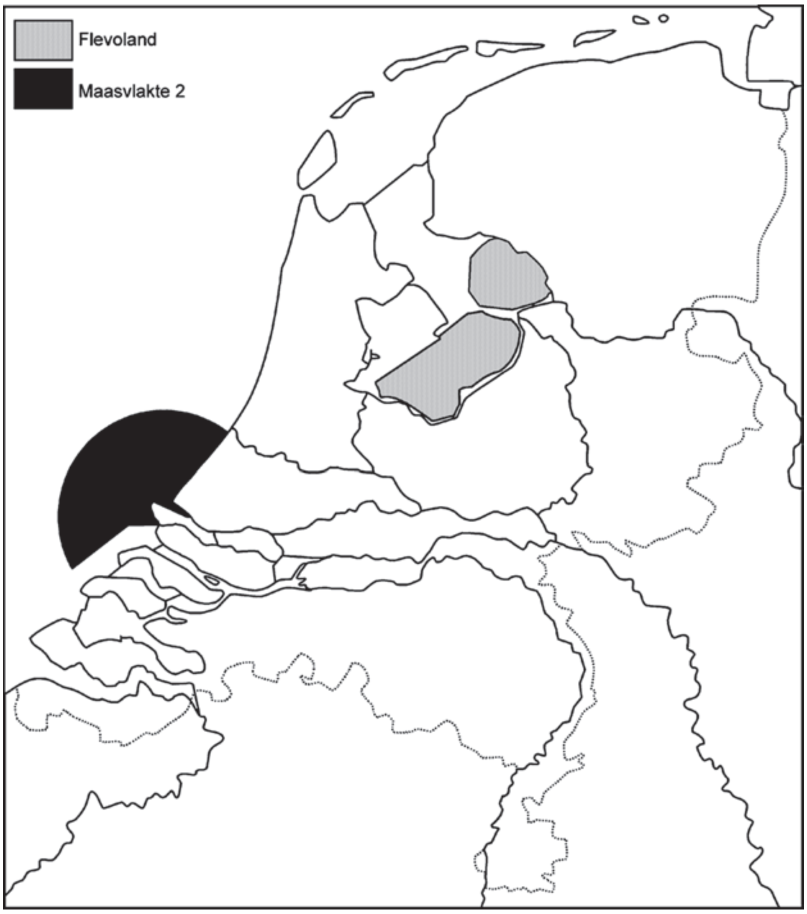


Figure 14.1 Location of the study areas discussed in this paper. The Maasvlakte 2 area essentially represents the search zone for sand extraction in the context of the extension of Rotterdam seaport on the coast

water, including that part of the North Sea which is defined as the Dutch sector of the Continental Shelf or (and the two coincide) the Dutch Exclusive Economic Zone. Taking responsibility for heritage in those extensive areas can only be effectuated selectively. The first association with underwater archaeology and maritime heritage is probably with ships and shipwrecks and this is quite rightly so. It also applies in the Netherlands. The Netherlands coastal waters such as the Wadden Sea are embarrassingly rich in shipwreck sites from many periods. Due to the soft sediments, organic material tends to be incomparably well-preserved. This means good preservation of the ships themselves as well as their tackle, cargo, and general inventory, even if these consist mainly of fragile organic materials. However, we also try to deal with remains from early prehistory, whether these were deposited in a maritime context or not. Deep gullies of present and former estuaries cut through landscapes and reveal far older Quaternary landscapes. Dealing with those landscapes is as great a challenge in maritime management and planning as dealing with the remains of the maritime past.

The setting

The North Sea Basin is an area of long-term geological subsidence over millions of years. Within the present coastline of the Netherlands the rising sea level and the subsiding and compaction of subsoil have been offset by rapid sedimentation. Seaward of the coastline this has been far less so. Preboreal and Boreal peat layers occur close to the seabed surface and are regularly being exposed. The same holds true for peats, clays, and gyttjas of earlier interstadials and interglacials. In between the inland and sea areas consecutive estuaries and tidal inlets have cut through the coastline. From erosive contexts, both in such channels and in outcropping surface deposits, we have been dealing with a regular flow of incidental discoveries of prehistoric archaeological material. Finds from the Leman and Ower Bank, the Brown Bank, and Europoort have become well-known through publications by Clark, Louwe Kooijmans, Verhart and others (Burkitt 1932; Clark 1932; Godwin and Godwin 1933; Louwe Kooijmans 1971–72; Verhart 1995). All such finds derive from disturbed contexts. On the other hand, the character of these objects such as well-preserved bone and antler implements implies recent disturbance only and locales with very good conservation.

Through the disciplined efforts of avocationals many more finds, and many more sites subject to present disturbance are coming to our attention at a time when three sociocultural changes are occurring. The first is that in all countries surrounding the North Sea it has become standard practice to include archaeology in all planning procedures implying spatial development of a certain magnitude. All these countries are party to the revised European Convention on the Protection of the Archaeological Heritage [Revised] that was concluded in Malta in 1992. All are bound by the Convention on Environmental Impact Assessment in a Transboundary Context concluded in Espoo, 1991. All have codified their planning rules or are in a process of doing so in order to implement these regulations and to cater for archaeological heritage management accordingly.

The second and third developments are that more conflicting activities and spatial interventions are relegated from land to sea and that as a consequence the seascape has gradually become involved in spatial and environmental planning. These processes imply political and administrative decision-making concerning all sorts of plans and developments such as aggregate extraction, construction of large-scale wind energy and hydro-energy plants, deep-mining offshore installations, pipelines, cables, seaward port construction, dredging of deep navigation channels, and anchoring or depot sites.

The three sociocultural changes make environmental and heritage issues part of maritime planning, which they have not been before. Inevitably this implies both obligations and challenges for archaeologists. One of the obligations the archaeological community faces is to assess clearly which areas are considered archaeologically important and which are less so. Where, in other words, an activity like aggregate extraction will create limited damage to archaeological values and where extensive research is to be — or can reasonably be — negotiated as a useful and acceptable measure of mitigation. The challenge is to make sure that such negotiation and mitigation results in optimisation of pre-eminently scientific results. Trying to provide for as yet undisturbed contexts is a method for doing so.

The general approach

As in all negotiation, asking too much is counterproductive in the end, and so is asking too little. If we want to convince and commit others, we have to accept that we often have to judge alternatives even before we can start to collect adequate information in the area concerned. Nevertheless, even if imperfect, we can refer to prior knowledge. We can start to model probabilities and that will help us to develop our intuition or expertise. It will give our prior judgements some sort of basis and controllable credibility, even if we cannot avoid making mistakes. After all, predictive modelling has to deal with many factors of uncertainty by definition. Let us try to explain the way we are presently developing crude modelling tools to map predictively the present-day potential for research in as yet undisturbed contexts.

We are dealing with three levels of analysis that need combining for the development of strategies and policies. These levels refer to the original formation of the archaeological record, what has happened since, and what happens upon discovery. Even for purely maritime remains such as shipwrecks we have chosen to make potential preservation the most important qualifying and discriminating factor (Deeben *et al* 2002). Although we will not include too much about nautical remains and previously navigable space in this contribution, the choice of preservation as the first level of preference actually helps to bring submerged remains from the prehistoric past and remains that have sunk since within the same framework of modelling, as long as we approach the issue at a crude and general scale.

Preservation, is partly dependent on what happened to the site originally, but more importantly it is dependent on what happened in the meantime. If erosion has demolished deposits that once existed, they are simply not there anymore. On the other hand other locales can be mapped where such deposits may have survived undisturbed. Geology, obviously, is the key. Let us, for instance, look at the Dutch coastal profile (Fig 14.2). In many areas it is concave and erosive, not a favourable environment. However, Tidal inlets that occurred at several positions along the Dutch coast during its Holocene development have resulted in convex ebb-tidal deltas. Several geological studies have demonstrated the preservative nature of such environments (Sha 1990). They occur in patches dispersed along the coast, but are, for instance, prominent in the combined Rhine-Meuse and Scheldt Estuaries in the south.

At a general scale the Quaternary geology of the Netherlands and the Dutch sector of the Continental Shelf are well studied and we have been able to analyse the situation and to identify areas of major maritime archaeological importance. These are indicated on the Indicative Map of Archaeological Values (2nd Generation). A specific map was developed for the North Sea (Fig 14.3). The dark shade in the map corresponds with a high indicative value. In order to cartographically distinguish between land and water in integrated maps different colour sets have been used. These reflect the slightly different methodologies

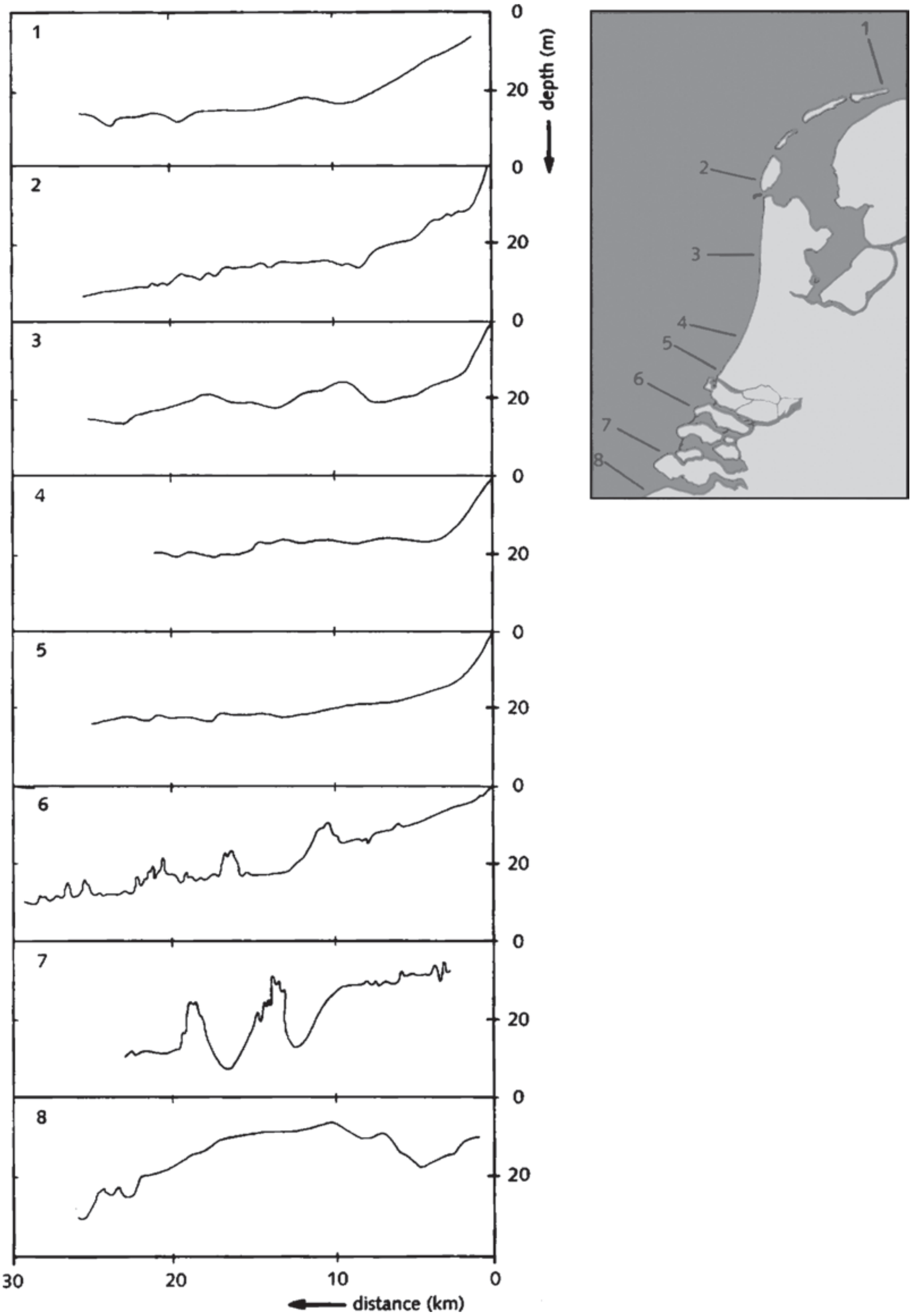


Figure 14.2 Profiles of the Dutch shore-face and their location (after van Alphen and Damoiseaux 1989)

followed for both areas, but have mainly been chosen to keep the map readable. In both sets, however, the dark shade corresponds with a high indicative value, whereas the lighter shades indicate zones with lower expectations. It should, however, be stressed that this does not equate with archaeologically sterile. An expectation of low density of high quality does not mean that no archaeological materials occur at all.

Without going into too much detail, it is useful to point to a few specific environments. The high energy zone where stranding has frequently occurred and where finds from all periods — including the Palaeolithic — abound, is nevertheless rated low. None of the Dutch beaches are sheltered. All finds seem to have lost their contexts. A specific flag has been put out for two deep sub-glacial valleys of Weichselian age in the

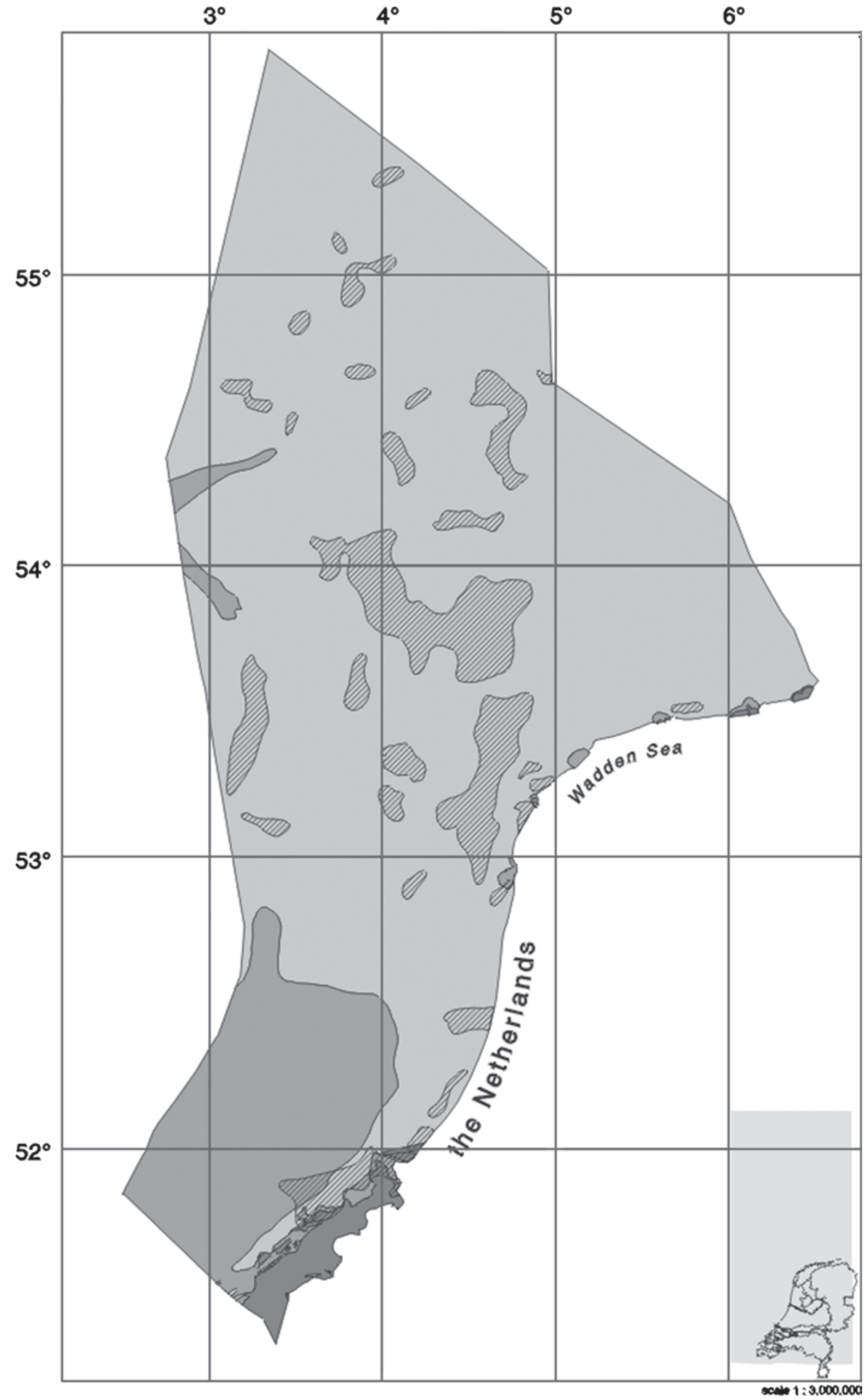


Figure 14.3 North Sea Indicative Map. Dark tones represent high potential value, shaded areas indicate presence of peat and gyttja

extreme north of the Dutch sector. Reaching to depths of around 20m or more below the sea floor and presently filled with younger silts, these valleys must truly have been a very protective receptacle for anything submerging at that spot. Whatever was present at the time of inundation was covered in an extremely protective covering. Imagine the number of shipwrecks as well as the *Stellmoors* and *Meiendorfs* it may contain, to mention just a few famous sites in a similar, but dry land setting (Rust 1937, 1943).

Another feature, rendered in grey in this general map, is the continuous occurrence of Quaternary peaty clays and gyttjas. It is those areas that merit specific attention from a point of view of palaeoenvironmental research. When superficial interventions are being planned in those areas, it is first and foremost that kind of research that can reasonably be negotiated in mitigation.

Lessons from submerged landscapes 'on shore'

As finds from the North Sea and the Baltic clearly show, large parts of prehistoric landscapes are still preserved. Certainly, erosion has occurred but the extent appears to be highly variable. An important conclusion has to be that the frequently assumed destructive force of marine transgression since the end of the last glacial was rather limited, in the sense that this did not involve overall erosion of earlier deposits. In fact, similar conclusions have to be drawn for previously submerged landscapes like those found in Flevoland (Fig 14.1) (Peeters *et al* 2002). Investigations conducted there during the last decade illustrate well what can be expected in the North Sea area. For a more general discussion of the potential effects of marine transgression on the different types of landscape in the central North Sea see Flemming (2002, 2003).

The province of Flevoland consists of the IJsselmeerpolders that have been reclaimed from the former Zuiderzee between 1942 and 1968. As such, the area represents a former sea floor. Pleistocene and early Holocene deposits are covered with clay and mud layers almost everywhere. Only near the eastern fringes and in areas where ice-pushed tills occur can old deposits be found at or close to the surface. In consequence, most prehistoric landscape features and relicts are hidden deeply below the surface. For this reason, the number of archaeological sites predating the inundation phase of the area was rather limited for a long time. Geological surveys led, however, to the discovery of several Mesolithic and Neolithic sites near Swifterbant.

Excavations demonstrated the importance of these sites, where not only flint and pottery, but also organic remains (including burials) were found (de Roever 1976; van der Waals 1977; van der Waals and Waterbolk 1976; Whallon and Price 1976). Later, more sites have been discovered, several of which have been excavated extensively (eg Hoge Vaart-A27, Urk-E4, Schokland-P14, Emmeloord-J97), all of them showing the enormous richness of the area (Hogestijn and Peeters 2001; Peeters forthcoming a; Peters and Peeters 2001; ten Anscher and Gehasse 1993; Bulten *et al* 2002). Archaeological investigations have shown prehistoric remains to be well-preserved, especially those that date just prior to the moment of inundation, or that are directly related to wetland environments (eg ritual depositions, fish weirs, etc). Analogous to other wetland areas and sites, the archaeological record of Flevoland shows an enormous diversity. The informative value consists not only in the quality of archaeological data. It also includes a rich body of palaeo-ecological data, including submerged forests. It is especially the possibility of studying the remains of prehistoric behaviour in the context of landscape data which makes the area of major importance.

It was quite surprising to find out that large parts of prehistoric landscapes are well-preserved, despite the environmental dynamics that occurred since the early Holocene. With the Pleistocene surface at depths ranging from some 2 to 14m below Dutch Ordnance Datum, inundation of most of the area took place between *c* 7000 to 4000 BP (Makaske *et al* 2003). From the Preboreal to Atlantic periods, the region transformed from a relatively dry hinterland into a wetland-dominated, lagoonal environment (the Flevo Lagoon). With the approach of the coastline increasing tidal activity led to the emergence of gully systems. However, peat growth managed to keep up with subsidence and water level rise, thus covering and sealing ancient land surfaces. Tidal activity only led to relatively local clearing of peat and other deposits up to *c* 3300 BP, after which the influence of the sea was attenuated as a result of the closing of the coastal barrier (Beets *et al* 1996; Beets *et al* 2000). This event triggered renewed peat extension and the development of large lakes, in which only sheet erosion took place. This type of erosion was also dominant since the development of the Zuiderzee with the opening of the coastal barrier by the end of the Middle Ages, although some extremely deep gullies cut through the subsoil.

Altogether, the degree to which erosion of prehistoric landscapes occurred is variable, but less dramatic than previously thought (Fig 14.4). This also holds true for Pleistocene landscapes. The few investigated profiles reaching well into the Weichselian coversands have shown palaeosols, gyttjas, peat, and good sedimentary sequences to be present almost everywhere. In the eastern and southern parts of the Netherlands, where the coversands are found at the present surface, sequences are often heavily disturbed. In Flevoland, Pleistocene land surfaces corresponding to different interstadials (Hengelo, Bølling, Allerød) seem to have been preserved over rather large and continuous areas. This offers possibilities for geological and palaeoenvironmental research, but also points to the potential of finding well-preserved Palaeolithic sites, especially close to Weichselian river valleys as found in the northern part of the province.

Even though the surface of the Flevoland polders is no longer a sea floor covered with water, archaeological heritage management is faced with many problems. These are specifically related to the fact that prehistoric land surfaces are

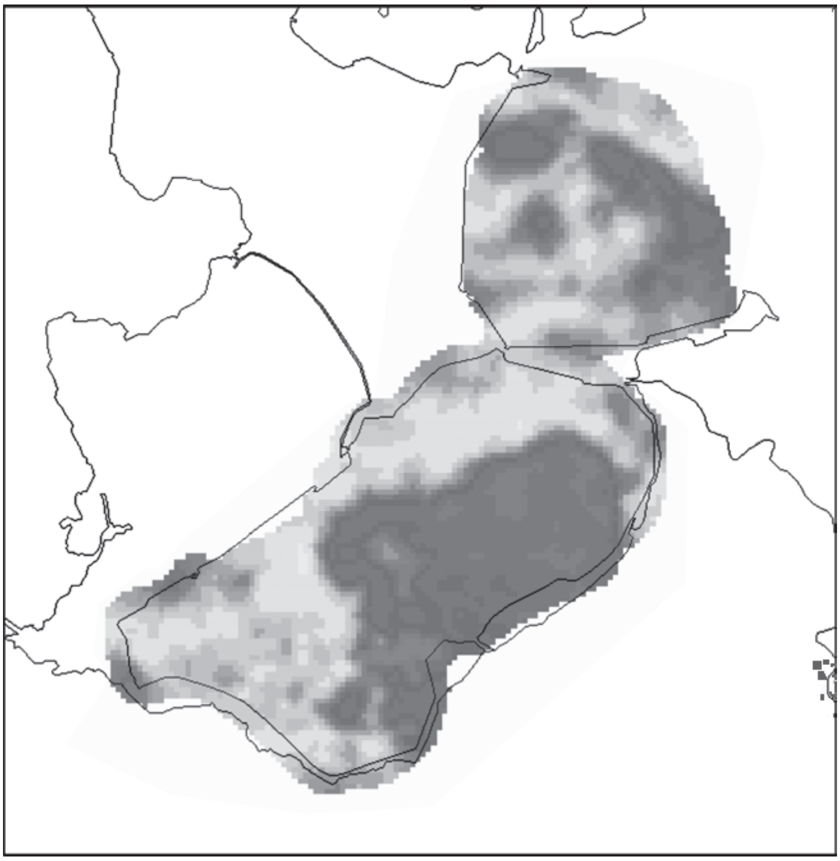
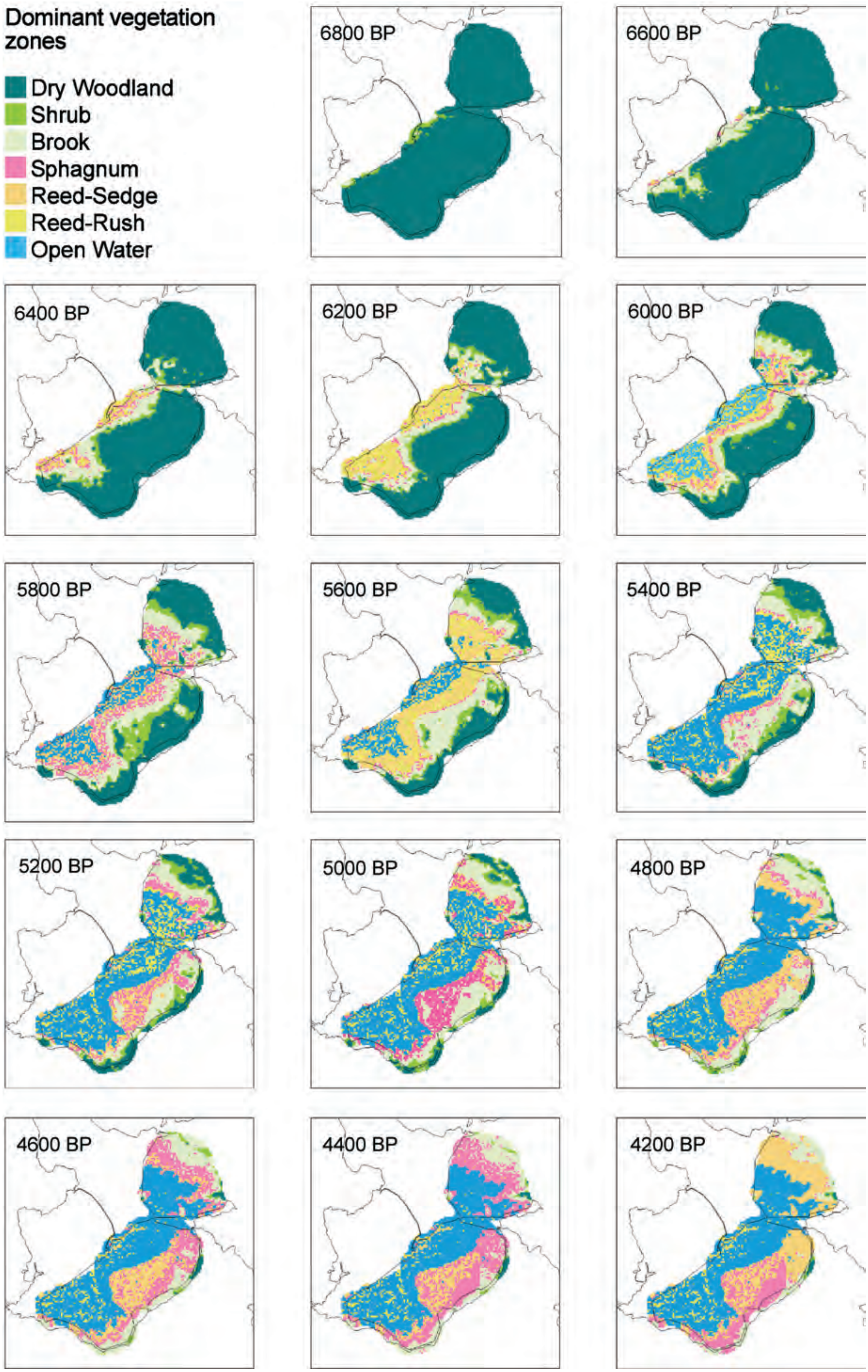


Figure 14.4 Map of the average intactness of the Pleistocene surface in Flevoland (grid-cell size: 500 × 500m). Dark tones indicate dominant erosive contact between Pleistocene and Holocene layers, lighter tones indicate dominant non-erosive contact between Pleistocene and Holocene layers (eg in situ *basal peat). Areas showing less erosion correspond to earlier Holocene gully zones which filled with peat, gyttja, and clay. Tidal activity did not result in complete erosion of sequences. Instead, Pleistocene surfaces at higher elevations appear to have undergone more extensive erosion due to later Holocene dynamics at the bottom and the fringes of large lakes and the sea*

deeply buried (mostly some 2 to 10m below the present surface) and covered with clay, gyttjas, and other sediments, thus making them invisible on the surface. Site resolution is poor, since we are mostly dealing with Mesolithic and Neolithic remains, often consisting of low density scatters of lithics, ceramics, and bones. Ritual depositions involve isolated objects or densely packed hoards. Fish weirs consist of vertical posts and wicker work. All such manifestations are scarcely traceable with geophysical techniques. Therefore, coring is the most common prospective technique employed. Clearly, however, the chances of actually identifying sites are rather low, whereas certain features (such as fish weirs or traps) are unlikely to be detected at all (Peeters, forthcoming b).

Considering these problems, models of landscape evolution (including erosion) and Mesolithic-Neolithic land use are currently being built using existing geological, palaeoenvironmental, and archaeological data, in order to provide a basis for the spatial prediction of archaeological phenomena in terms of qualitative and quantitative variation (Fig 14.5) (Peeters forthcoming c). Such models are needed to enable the design of prospective strategies on the one hand, and to influence spatial planning of the modern landscape on the other hand. Of course, we are fully aware of the pitfalls of predictions informing

Figure 14.5 Model of palaeogeographic developments in Flevoland for the time span 6800–4200 BP, showing the transition from a dry forest dominated landscape toward a distinct wetland landscape. Vegetation zones have been defined as dominant assemblages related to groundwater level. The model integrates data on structural water level rise, capillary groundwater level rise, peat growth and clay sedimentation rates, as well as major erosive events (see Peeters forthcoming c)


Dominant vegetation zones
Dry Woodland
Shrub
Brook
Sphagnum
Reed-Sedge
Reed-Rush
Open Water
6800 BP
6600 BP
6400 BP
6200 BP
6000 BP
5800 BP
5600 BP
5400 BP
5200 BP
5000 BP
4800 BP
4600 BP
4400 BP
4200 BP

prospection, which in turn informs the next round of prediction (see for example Price 1995, 424). Nevertheless, we presently see it as a fruitful approach as long as one is aware of those pitfalls. Prospective surveying of such areas and excavation of sites at considerable depth is extremely costly. For this reason, predictive models can help to focus time and money from prospective projects on specific problems, or even prevent the need for such research when 'high risk' zones can be identified in an early stage of planning.

The circumstances described for the Flevoland polders certainly have their analogies in areas offshore and buried in convex ebb-tidal delta sediments on the coast. So far we have only looked at them at a very crude and general scale. Let us now home in to a specific project area.

A specific project

At a more detailed scale the information is evidently more equivocal, but it starts to guide choices, for instance regarding the extraction of large quantities of building material for the seaward extension of the port of Rotterdam. As elsewhere, many new economical activities are foreseen in the coming years. To cater for these a new industrial area has been planned, to be built seaward of the present coast. This Maasvlakte 2 project (Fig 14.1) combines the construction of new docks with large-scale sand extraction offshore. If we zoom in into the construction area itself, the generalised indicative maps show different zones (Fig 14.6). The border between a high indicative value and a middle or low one, however, is rather arbitrary at the project scale. Nevertheless it enables us to convince the developing authority to carry through more detailed mapping with shallow acoustics and to deploy a strategy. Fortunately, enormous amounts of geological data are now available, permitting exploration of the research potential of areas prior to any further (costly) steps 'in the field'. Currently, joint efforts of the Municipal Archaeological Department of Rotterdam, Leiden University, the Netherlands Institute of Applied Geosciences, and the National Service for Archaeological Heritage are leading to the formulation of a research framework, which should structure further investigations. Apart from historical shipwrecks, finds from the area of interest especially concern Mesolithic bone and antler implements, and Pleistocene faunal remains.

The specific, rather extensive, port extension project coincides with the extraction areas where magnificently preserved Mammoth faunas have been retrieved as well as Eemien gyttjas and remains of drowned oaks and other trees from presumably that same period. So far, almost all of these finds are done out of context in the course of several decades (Louwe Kooijmans 1971–72;

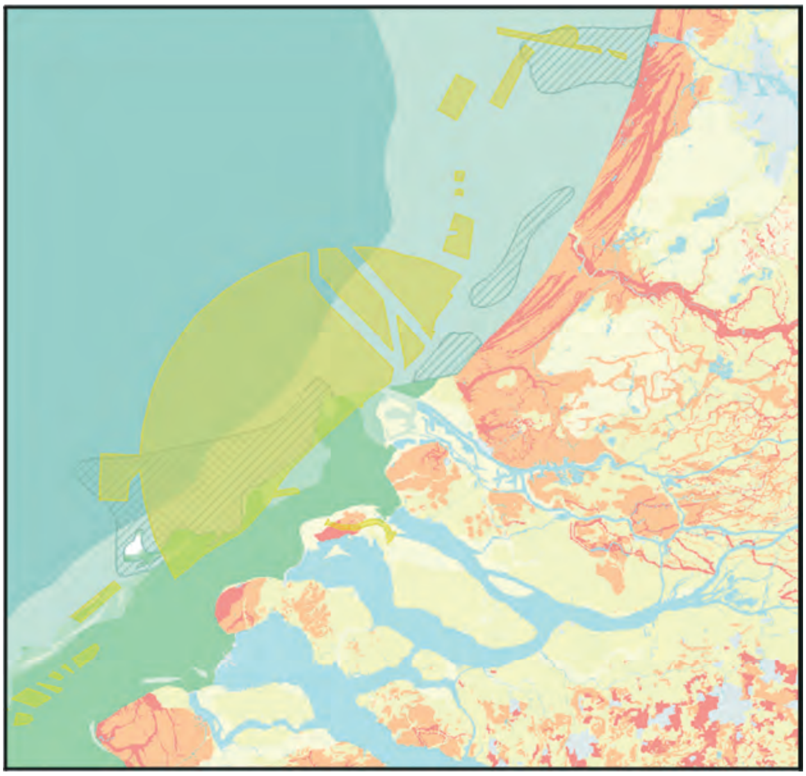


Figure 14.6 Part of the Indicative Map of Archaeological Values (IKAW, 2nd generation) that is relevant for the seaward port extension of Rotterdam. The yellow semi-circle delineates the target-area for the extraction of 400,000,000 cubic metres of sand

Verhart 1988, 1995). Nevertheless, the character of the materials, combined with knowledge of the geological situation of the probable primary locations of origin, make it possible to distinguish between two categories of prehistoric find contexts:

1 At an average depth of some 18–20m, a peaty clay layer ('Velsen Layer') is discontinuously present. The deposits correspond to the early Holocene inundation of the area and are without doubt the context from which the Mesolithic barbed points and other objects originate. The perfect preservation of these bone and antler implements points to the importance of the Velsen Layer with regard to research on Mesolithic behaviour. In this situation, where the absence of Mesolithic knapped flint is remarkable, it is very possible that we are dealing with the archaeological reflection of behaviour related to a specific form of hunting (perhaps marine mammals?)
2 In areas where Holocene deposits are absent, one is essentially dealing with erosion channels which cut into the Pleistocene deposits. These provide the context from which Pleistocene faunal remains originate. These materials clearly represent a mixture of early and late Pleistocene assemblages. Typically, middle Pleistocene remains seem to be lacking. So far, it is unclear what causes this hiatus. Another interesting issue concerns the possibility of a Weichselian coast in the southern North Sea region, regarding finds of probable late Pleistocene marine mammals.

A quick scan of existing geological data (corings and sonar) therefore provides a good basis for the delimitation of areas of potential importance to specific research questions. As we have seen, these questions are not necessarily strictly archaeological, but are also related to environmental and palaeogeographical issues which are of importance to the understanding of archaeological patterns. Furthermore, it should be stressed that prehistoric behaviour did not always result in archaeological manifestations in terms of artefacts and features. For instance, growing evidence for Mesolithic vegetation management principally comes from pollen records and the charcoal contents of peat sequences. Therefore, it is essential to adopt a landscape-oriented perspective for the formulation of research frameworks and the design of strategies.

As is the case for the Flevoland polders, a useful steering instrument for research can be provided by predictive models, which integrate aspects of landscape development (palaeogeography, vegetation, fauna), sedimentary and erosion regimes, and prehistoric behaviour. When contrasted with actual geological and archaeological data, such models permit us to draw inferences about where one can expect parts of palaeo-landscapes to have been preserved, as well as about the qualitative and quantitative character of potential information sources in relation to research questions. Subsequently, suitable methods and techniques can be applied and developed in the context of prospective research and model testing.

The technique of extraction to be used in the Rotterdam project implies the predominant use of trailer-suction dredgers. Presently they are extensively in use to deepen the channels in the approaches to Rotterdam that cross the project area. Such trailer-suction dredgers loosen the sediment with high-pressure waterjets and suck in the fluidised material. There is no way whatsoever in which we can introduce archaeological observation into the process itself. However, in the fluidising process, sticky bits and solid material will partly be cast aside. Contexts are disturbed and lost, although objects with adhering sediment are not uncommon. A portion of this material is being collected by means of trawl-fishing with ground-tackle on a voluntary collecting basis (see Glimmerveen *et al* this volume). It brings us surprising results. This is even more so considering the fact that it cannot be more than a very small portion indeed of what was disclosed, moved, and destroyed in the process. In addressing archaeological mitigation in a project of this scale — 400,000,000 cubic metres of sediment to create the first 1000ha of port facilities — this information is strong input. Considering the civil engineering techniques to be deployed it is not easy to influence what will happen upon 'discovery'. In discussing, prioritising, and negotiating the archaeological work to be executed as part of the project we will probably end up by including some sort of secondary collecting from the disturbed context. It would not, however, be satisfying to let that be all. Some of the work will include cutter-suction-dredgers and we want to prevent 'hard detection' of discrete archaeological objects (read historic or prehistoric shipwrecks). In the hard detection process the teeth of the cutter and the suction pump are both blocked by historic wreckage to the chagrin of both dredging boss, client, and archaeologist. In consequence, one of the lines of research negotiated already is targeted at identifying discrete objects with a range of surveying techniques. Another line of research is a shallow acoustics survey and coring program. It aims at a better assessment of the continuous presence of — in this case — Preboreal peat. On the basis of that information we will choose a small section for detailed research as an acceptable mitigation for the destruction of a larger area.

Normally, detailed research of a small section would mean excavation. Under the circumstances it will mean sampling, removing the sample or samples, and dismantling or excavating them elsewhere. That is to say at any spot other than at 22m deep in a murky and unstable dredging quarry. The sample size we are presently discussing is boxes in a size-order of two 40-foot containers combined.

Such an approach, aimed at getting to the context of an area rich in contextless finds and at combining large-scale disturbance with contextual research, may, perhaps, be successful. On the other hand it is something of a wildcard. It may miss. It is a risk that is acceptable within this huge project's context, although not necessarily anywhere else.

A next step

Although the example above may seem to be 'innovative' in its practical elaboration, it is basically conventional archaeological heritage management. It is a conventional approach, seeking the limits of applying the European Malta Convention in technically extreme and environmentally marginal circumstances. That is reason to make a few additional remarks. What starts to guide this and other projects is the firm wish of developers and clients to mitigate. In terrestrial projects and land-related regulations catering for archaeology normally implies a process of avoiding damage and if not, of excavation. In large-scale hydraulic projects clients and archaeologists are trying to find adequate, semi-parallel, solutions. The best solutions may not necessarily turn out to be excavation of what will otherwise be lost. Sometimes it may prove to be more adequate to accept that archaeological values will be lost and to mitigate this with targeted research in a wider zone than that immediately affected by the development in question. In that approach 'mitigation' is not just making sure that the loss of archaeological values is minimised by documentation and evaluation of those very values. In that approach the loss is compensated by a gain elsewhere, in a related context. It is 'compensation' in the way that our environmental colleagues use the term.

As of 1 January 2003 the Dutch mining regulations that cover the exploitation of mineral resources in Dutch territory and in the Netherlands Sector of the North Sea Continental Shelf have changed (Mijnbouwwet, 1 January 2003). One of the implications is an obligation for the offshore oil and gas industry to include archaeology and take care of heritage in their operations. In England taking care of heritage in the North Sea is also being backed by new regulations (National Heritage Act, 2002, Chapter 14). It is evident from the very start that the institutional and regulatory approaches on both sides of the North Sea will be slightly different, but in substance we want the same thing and in practice we will be dealing with the same companies. So it is an asset that we are simultaneously on the same route, and that we can communicate about how to make progress.

The indicators from disturbed contexts, so vigilantly collected by avocational archaeologists and collectors will help to define research that serves the purpose of mitigation of large-scale disturbances. It is the prehistorians studying the early past from whom maritime heritage managers need a strong input. In the end that effort is worth while and for two reasons.

The first reason is the attractiveness of coastal zones for human beings. Coastal areas show the greatest population density in all those periods over which there is sufficient information to assess it. We may assume that this has always been the case. The high sea level in our present warm period consequently implies that we are in a bad position to study perhaps the most intensely inhabited areas of early prehistory (Masters and Flemming 1983; Bailey and Parkington 1988; Maarleveld 1994). The few coastal settlements that have been within reach date from warm periods, comparable to our own. For much of early prehistory our knowledge is fully dependent on inland sites, which perhaps we must assume not to be fully representative.

The second reason is independent, but further supports the argument. Conditions determine degradation and preservation. Wet taphonomic processes may have continued in persistently wet or submerged environments. They warrant preservation of varied organic materials. What happened in the meantime causes a strong bias in our present data. Under variable or dry circumstances many materials have simply not continued to exist.

It is for those two reasons that the submerged archaeology on the shelves of the Earth's continents may prove to really add to our knowledge and understanding. They already provide us with data from disturbed contexts. They will do even better if undisturbed contexts come within reach. As archaeologists we have an obligation to supply mitigatory sponsors with prior knowledge and ideas. In that way we can negotiate targeted research as compensation for loss elsewhere. In that way also we can influence what happens upon 'disclosure' or 'discovery' of important archaeological sediments. At the National Service for Archaeological Heritage we have started to create input regarding the Netherlands Sector of the North Sea Continental Shelf in GIS and predictive maps. These are still shamelessly crude, but they can be refined at each and every mitigation. We have started all this and the work and reasoning presented here on the assumption and conviction that in the end we can manage.

Summary of discussions and drafting groups

This chapter combines and summarises the general discussion points which arose at the end of each paper, followed by reports of the conclusions of each of the drafting groups. There were three drafting groups:

1 Legal regime
2 Relations with industry, existing and future
3 Funding for research.

General discussion

A recurring theme during the workshop was the multidisciplinary complexity of the systematic study of offshore prehistoric deposits. Sites containing archaeological materials *in situ* are being found both by chance and by professional surveys. The existence of so many known sites, together with the implied existence of many more unknown sites, creates an immediate responsibility and obligation for the archaeological authorities of the coastal states. The nature of this obligation was discussed in a session on the legal infrastructure for offshore prehistoric archaeology (Maarleveld). (References without dates refer to chapters in the present volume).

Other related topics included the different components of climate during the Pleistocene glacial cycles; the current knowledge based on computer modelling regarding the size, thickness, and boundaries of ice sheets at different dates; the global variation of sea level controlled by the global ice volume; the position of coastlines at different dates; seabed mapping techniques; surveying and data management; stratigraphic excavation of archaeological sites by divers; predictive models indicating the potential for site occurrence and survival; palaeontology; dating technologies; analysis of ancient DNA; conservation strategies; and the management of diving safety.

Given the complexity of the subject, and the implied cost of undertaking research and site preservation, taking all aspects fully into account, it was necessary to consider the intellectual and archaeological value of conducting the work at all, as opposed to allocating the equivalent effort onshore (Bailey). There is an ironic paradox here, because, if professionals conclude that the work is too expensive in relation to the gain in archaeological knowledge, the submerged prehistoric sites will continue to be found by sports divers, amateur archaeologists, and fishermen, who will, even if sincerely interested in the subject, inevitably work to lower academic standards. It is therefore essential that we identify working methods and procedures which provide the maximum efficiency in terms of knowledge gained per unit of expenditure, and to focus the professional resources onto those aspects of research and site protection which can be best justified.

In view of the presumed or apparent cost of fieldwork on submerged sites, and the legal and safety aspects of diving within the regulations existing in some countries, it is tempting to suggest a linear or Cartesian approach to the subject, spending a few years building up logical background data, mapping, devising, and running computer models, making predictions, and then only to dive on a few high priority sites several years into the future. This approach has disadvantages. As already mentioned, submerged prehistoric sites are being found all the time by sports divers, fishermen, and in the course of coastal civil engineering and dredging. Over 2000 submerged Mesolithic sites have been recorded by professional archaeologists in the Baltic waters, often with the help of sports divers. A few more sites have been surveyed and excavated in the English Channel. We know that these sites exist, and, by implication, many thousands more also exist under the waters of the north-west European seas. We also know that sites are eroding, and that winter storms wash away large quantities of peat, clay, and sand from submerged archaeological sites, scattering artefacts and bones, while destroying the stratigraphic context (Gron, Momber, Fischer, Flemming). It follows that both research knowledge and site preservation would benefit greatly from archaeologists diving on known sites as soon as possible. Also, within reason, there is a balanced case to be made for discovering and monitoring new sites in order to study them before they are eroded. In this strategy modelling and prediction, and the other supporting disciplines, become a framework within which the subject as a whole develops and progresses.

When experts and specialists with many different skills start planning to work together we need to delineate the relative roles and contributions of each discipline. One task of the workshop, and of this book, is to show how the components fit together, each being an essential part. This analysis is designed to preempt any controversy between the disciplines or suggestions, for example, that predictive modelling is more important than site archaeology, or that the climate and ice-age research must reach some stage of near-perfection before it is worth searching for palaeoshorelines, and so on. Each component of the subject is worth supporting in its own right in order to advance the subject as a whole. Each major field project requires a logical design which integrates the available knowledge at the time, and responds to the priorities created by the site location, development status, or threat of erosion or other damage.

It is appropriate for English Heritage, or other agencies, to support projects which focus on aspects of Continental Shelf palaeo-climates, technical aspects of acoustic seabed surveying, palaeontology of marine mammals, etc, insofar as each contributes to the wider understanding of offshore prehistory. Predictive models can be developed and tested in parallel with the discovery and survey of submerged sites, which themselves help to calibrate and improve the reliability of the models. The criteria for identifying the most favourable location of occupation sites are not necessarily the same on the submerged coastlines as on the present dry land area. New data from the floor of the North Sea will be needed to design and refine the best models. Additionally, understanding the landscape and terrain within which the sites exist provides essential information for interpreting the cultural context.

It must be stressed that a 'do nothing' strategy is not an option. We know now that prehistoric archaeological sites were formed on the Continental Shelf, that some deposits can survive marine transgression with stratigraphic integrity (Fischer, Gron, Momber), and that sites are being destroyed by natural and anthropogenic processes (Momber, van Kolfschoten, Glimmerveen *et al*).

The authors of the chapters of this book are all experienced researchers in marine prehistory, archaeological survey, and excavation underwater, or the regulation of marine archaeology. It is not surprising that they are enthusiasts for their disciplines. However, many of the other participants at the workshop were specialists in topics such as Pleistocene palaeontology, wetland archaeology, or marine geology, who could have been justifiably sceptical of either the importance or feasibility of submarine prehistoric research. Another aim of the workshop, and this book, is therefore to show that submarine prehistoric research and conservation is an integral part of the mainstream of 21st-century archaeology, not a curious fringe subject.

Legal regime

General comments

The sea floor of the North Sea is all within the Continental Shelf area of the coastal states, and the borders between states' jurisdiction are defined by median lines and adjacent boundaries. Many special national laws apply to the seabed within the territorial sea out to twelve nautical miles (nm) from the coast, while the legislation beyond that usually applies mainly to industrial exploitation of the seabed that is the Continental Shelf. The archaeological management and conservation of shipwrecks more than 100 years old has been addressed by both national and international legislation, but is not considered in this volume. The participants discussed the legal matters which relate to the relics of human prehistoric occupation of the seabed, and the associated relict landscape.

Topics of consideration

Participants considered the following topics:

(i) Regulation and management of prehistoric archaeology in wetlands, on beaches, and the intertidal zone
(ii) Responsibility for and regulation of prehistoric archaeology on the seabed within the 12nm Territorial Sea, and to the limits of the Continental Shelf
(iii) Diving legislation, health and safety as applied to scientific-archaeological diving, and the legal position of university and research staff, and amateur archaeolgists. Compatibility of diving safety laws, training standards, and operational regulations
(iv) Legislation and directives specifically intended to protect submerged prehistoric sites and artefacts: national, agency, county or regional policies. Procedures for scheduling, protecting sites, or mitigating impacts of development.

In Norway the legislation on marine archaeology is in a process of reform, but it still refers to single sites, rather than to landscapes. In the UK the Strategic Environment Assessment Directive required compliance by July 2004, and in addition there are regulations for the environmental impact of specific projects. UK regulations applying to offshore oil and gas activities stem from the Directive 2001//42/EC of the European Parliament and of the Council on the assessment of the effects of certain plans and programmes on the environment. Annex 1, para (f) of this document refers to the 'significant effects on… cultural heritage including architectural and archaeological heritage, landscape and the interrelationship between the above factors'. The British Department of the Environment, Food, and Regional Administration (DEFRA) is looking at how other industries are regulated. In practice, shipping and fisheries are regulated by European directives and agreements. The so-called Habitats Directives of the EC are particularly onerous.

English Heritage and Historic Scotland have designated legal responsibility for the prehistoric archaeology (and historic shipwrecks) out to the 12nm limit of territorial waters, and in both cases these agencies are prepared to consider the implications of sites which may be discovered on the UK Continental Shelf outside the 12nm limit.

In the UK there is no state ownership of antiquities and no mandatory reporting of archaeological discoveries.

In the Netherlands there is no distinction made between shipwrecks and prehistoric landscapes. The North Sea Continental Shelf is being studied as a planning area, and the Ministry of Culture acts as a legal adviser. There has been cooperation between serious amateur palaeontologists and fishermen during the last twenty years.

The Danish Territorial Sea and Contiguous Sea is 24 sea miles wide from the coast. In spring 2003 Denmark ratified the United Nations Convention on the Law of the Sea (UNCLOS). The present plans indicate a new Act for Cultural Heritage, and the ratification of the Paris Convention. As a result, submerged archaeological sites and ancient shipwrecks will be protected in the area between 24 and approximately 200 nautical miles from the coast.

On the German coast there are three Länder with relevant interests, and there are slight differences in the regulations from Länder to Länder, for example, in the age of sites which are protected. Cultural resource management is limited to the territorial waters, and the relevant state laws of each Länder. Planning controls require that the polluter pays.

Relations with industry

Topics of consideration

Participants considered the following topics:

(i) Compare for each country the existing degree of cooperation or collaboration with:

a) Fisheries
b) Aggregated dredging
c) Offshore oil and gas
d) Coastal engineering.

(ii) What kinds of contacts, regulations, or agreements have been found to work?

(iii) Collaboration and involvement of industies:

a) Various working relations exist with different industries. What would be the best practical relations which could be developed with different industries, using different types of governmental or non-governmental mechanisms, to protect and research submarine prehistoric remains in the North Sea?

b) Benefits and disadvantage of the following types of agreement:

- Informal non-binding agreements
- Non-statutory directives and quasi-legal agreements
- Regulations and controls implemented under preexisting statutory legislation
- Directives requiring environmental impact statements
- Reporting schedules
- Mitigation and avoidance.

(iv) How is each type of relationship relevant to the dierent industries?

(v) Positive benefits of industrial activity, and positive collaboration with academia:

- Getting archaeological priorities into the early planning stages
- Random recovery of artefacts which help to trace deposits
- Acoustic surveys which reveal probable areas of site occurrence
- Data on submerged river beds, shell gravels, dunes, peat, and other geomorphological features
- Access to archives of acoustic data and cores
- Access to high precision bathymetry
- Access to video and other records from pipe and cable routes, and *foundation surveys* for platforms.

Fisheries

Sixty per cent of the European Continental Shelf is trawled by bottom trawls each year according to the International Council for the Exploration of the Seas (ICES). This process disturbs the sediments to a depth of 50–80mm each time a trawl passes. At present no legislation applies to this disturbance, although several tonnes of Pleistocene mammal bones are retrieved by fishermen each year. The context of the bones is not known. Academics have been aware of this flow of palaeontological material since before 1970, and there is informal communication between the interested museums and universities, and the representatives of fishermen.

In Holland there is a Dutch Association of Pleistocene Mammals (WPZ) in which amateurs and professionals have worked together during the last twenty years. Members of this group have published professional scientific papers on findings from the North Sea, and this type of collaboration seems to be an essential ingredient for success in future.

Recovered bones in the Netherlands are sorted to identify good specimens which are valued by collectors, and some amateurs maintain collections to a very high standard. In the UK, fishermen in the Solent retrieve flint tools from the seabed, and collect them as a hobby. Again, informal contacts between fishermen and academics exist, but it is difficult to grasp the complete range of artefacts retrieved, and sometimes difficult to obtain information.

In Holland there is now debate as to whether Pleistocene mammal bones constitute archaeological material, in which case they would all be covered by antiquities law. Viewed broadly, the bones have an archaeological significance because they provide information on climate, ecology, land/sea relationships, fauna, vegetation, and the food base for human hunters. A few bones are found to be carved, and the information is then reported to the archaeological authorities, although the artefact can remain in the possession of the finder.

It is impossible to prevent bones being disturbed by fishing trawls, but closer cooperation would probably reveal a great deal more information from the finds. There is considerable willingness to arrange such collaboration. The location of finds needs more careful plotting and monitoring. The attachment of video cameras to nets for a few experimental runs might reveal a great deal about the exact location and nature of occurrence of mammal bones in the seabed. Study of the bones on a statistical basis, using a variety of tests, has the potential to reveal species migrations, hunting patterns, species evolution through time, and species selection and evolution during the process of domestication.

Aggregates dredging

In the UK a working relationship has been established with the British Marine Aggregates Production Association (BMAPA), although not all companies subscribe to it. Guidelines have been published, and Wessex Archaeology has been tasked to develop a protocol for reporting finds at the wharf-side and at sea. Much has developed from environmental assessment practice. The developers have project managers with science background and interests in these areas. A levy on the industry supports research, and good working relationships, result in offers of data. Occasionally the larger stone artefacts are recovered when aggregates are sieved and sorted at the dock.

The Dutch experience is different, in spite of the large quantities of Pleistocene mammal bones known to exist in areas of dredging. The Dutch aggregates industry has not been helpful or interested. They are not covered by environmental impact requirements, and sites which need preservation must be identified specifically in order to get protection.

It was agreed that data obtained by aggregates companies should be studied and archived to identify areas of potential importance for prehistoric archaeology. This could include acoustic data, cores, and samples.

Offshore oil and gas

The oil and gas industry is by far the largest operator in the North Sea in terms of financial commitment, but the footprint on the sea floor of platforms and pipelines is relatively small. Recent British legislation implementing European directives now requires companies to include consideration of the impact on submarine prehistoric remains when planning operations and conducting environmental assessment. The Department of Trade and Industry has organised workshops on strategic environmental assessment for the British sector of the North Sea, including consideration of submarine prehistoric archaeology.

The technology of surveying in offshore hydrocarbon operations provides an opportunity to obtain a great deal of relevant data for prehistoric archaeology. Since the landscape and soils are important indicators of palaeo-climate and vegetation, it is useful to have high precision swath bathymetry, shallow seismic sub-bottom profilling, and core data for the upper few metres of sediments. These data types are often obtained when surveying the route of a pipeline, or preparing the geotechnical analysis prior to installing a platform.

Oil and gas companies will make data available if it can be shown to be relevant to research. Large companies are moving out of the southern North Sea at the moment, and small companies are historically less inclined to be helpful. There is a historical license requirement on big companies to retain the exploration data, and it is desirable that these data should be available. However, long-term curation of data is very expensive, requiring regular verification and conversion between media types. A suitable metadatabase would be important so that such a large data-holding could be accessed efficiently.

Coastal engineering

The government is generally the client for most coastal engineering work, either directly or indirectly. Activities include coastal protection, beach replenishment, harbour works, dredging of navigation channels, construction of bridges and tunnels, and installatioin of coastal and offshore windfarms. In the past the relations with developers have been very variable, and there has been a lack of strong curatorial control, but this is improving.

Dredging works can recover timber and other large artefacts which may be seen as the dredge spoil comes on board. Smaller objects would require careful examination of very large quantities of material, and therefore this usually does not happen. In the past, information has generally come from retired workers, and significant finds have resulted from this. More effort is needed to maintain contacts with key operators, and to exchange information.

In UK the Environment Agency is designing a strategy for coastal maintenance which is supposed to take account of the possible damage to preshistoric sites. The EU has funded a programme on the study of coastal change around the Isle of Wight, and this includes a study of coastal instability, and analysis of the sedimentary archive and historical changes.

Conclusion on collaboration with indsutries

Relations with the different coastal and offshore industries are generally developing and changing in a positive way, partly as a result of European Directives and national legislation, and partly as a result of *ad hoc* consultation. There is a pressing need for a more comprehensive and consistent approach to the different industries, and for commonality across national boundary lines within the North Sea. At present, successful negotiations and arrangements with one industry could be undermined, inadvertently, by failure to obatain similar or equivalent agreements with another.

If legislation is going to require commercial companies and contractors to obtain data and samples for research and conservation purposes, the academic community must organise itself to receive and interpret the data, so as to advise regulators on priorites.

Fundraising

Topics of consideration

A review of nationally available funding sources, the range of agencies in different disciplines which might support offshore prehistoric research, and possible sources of European funding were considered. Funding sources were discussed in three categories:

- Pure research funding
- Government funding
- Other sources.

In the UK the following bodies support archaeology with grants: British Academy; the Arts and Humanities Research Board; the Natural Environment Research Council; UK Home Country heritage agencies; the Leverhulme Trust.

Considering the issues more generally, the participants stressed that competition for funding is very intense in the field of archaeology and the humanities. Several arguments were suggested for raising the profile and the chances of success for funding for offshore prehistoric research. These were:

- Linking marine prehistoric archaeology with related environmental research such as climate change, evolutionary trends, DNA studies of modern populations, coastal change, marine pollution, environmental conservation, sea-level rise, human migration and dispersal, etc
- Creating a consensus for the major strategic research goals, with a research agenda of topics to focus upon
- Requiring some polluting companies to pay compensation rather than to undertake mitigation, and to provide compensation in the form of goods and services for research
- Conducting applied research, and obtaining funds for new technologies, or the application of existing technologies in submarine prehistoric archaeology
- Individual projects can obtain extra funding from local government, private companies, and charities.

In the European context the group considered Interreg III, NATO Science Committee, Culture 2000, and the Leonardo Project. Interreg III is focused very much on management issues, with deliverables seen as recommendations in support of the planning process, rather than fieldwork.

The task of understanding the prehistory of the submerged landscape of the North Sea is so great that continuous collaboration and exchange of information is needed. This necessitates collaboration between university research departments, government laboratories, museums, amateurs, and offshore industries.

Conclusions and recommendations

Preliminary note

The workshop was convened by English Heritage, and the participants from other institutions attended in their own right as individuals, not representing their institutions officially, nor any other organisation or committee. Several representatives and officials were present from different components of English Heritage. The conclusions and recommendations of the workshop therefore fall into four categories:

1 Conclusions based on professional expertise, being matters of expert opinion, and not requiring specific action by English Heritage or other agencies, although they may influence future policy
2 Recommendations to English Heritage for actions, policies, or reviews which can be taken up by the appropriate administrative body within English Heritage
3 Agreements among the participants to take further actions which do not require financial commitment or policy decisions by their own institutions
4 Recommendations regarding desirable actions in principle, but not being directed at a specific agency.

Conclusions

(i) Understanding the prehistoric archaeology of the north-west European Continental Shelf is an essential part of understanding the prehistory of Europe. In particular the recolonisation of the British Isles after the last glacial maximum, and the movement of Mesolithic peoples into Scandinavia, depend critically upon understanding the prehistory of the North Sea

(ii) The North Sea and English Channel constitute a large area of potential terrain which could support vegetation, fauna, and coastal resources exploitable by Palaeolithic and Mesolithic peoples. This area should not be regarded as a land bridge, but as an occupied territory with its own special environmental conditions, sequence of climatic changes, culture, and evolution of technologies

(iii) Submarine prehistoric sites survive in protected low energy environments in the Baltic Sea, and the Solent. Artefacts without stratigraphic context have been retrieved from offshore the Netherlands and across the southern North Sea. One site is known from a depth of 20m on the French Channel coast. In principle prehistoric occupation sites in locations which had low wave and current energy at the time of inundation should survive intact at many places in the North Sea

(iv) Submarine sites can survive with sufficient stratigraphic integrity to provide evidence of dwelling patterns, village structure, flint-knapping sites, lithic technology, waterfront structures, fish weirs, hearths, food remains, canoes, paddles, and burials with human bones. This array of materials provides a sound basis for cultural and social interpretation.

(v) North Sea prehistoric sites close to shore in water depths of 5–15m can be studied and excavated using scuba-diving techniques or surface-supplied air diving. The potentially most interesting sites further offshore are likely to be in the central southern North Sea in the neighbourhood of the slopes, valleys, and ancient shorelines within 50km of the Dogger Bank and Brown Bank. (No artefacts or Pleistocene mammal bones have been found on top of the Dogger Bank, in spite of the fact that it is intensively trawled by fishing vessels). Detection and study of sites in these environments will require the use of swath bathymetric acoustics, sub-bottom profiling, and support for seabed intervention using remote operated vehicles and surface-support diving to depths of the order of 30–50m. This is technically feasible, but will need the progressive development of a case for the research before expenditure on this scale would be justified.

(vi) The role of offshore industry, if suitably regulated, is potentially beneficial, since industrial equipment can reveal the presence of submarine prehistoric sites, or environments conducive to human occupation. The risk of damage to sites has to be balanced against the advantage of discovering sites in areas where it would be impossible to justify spending academic funds on a speculative basis. This judgement depends upon a monitoring and licensing regime for marine industrial processes, acoustic surveys, coring, drilling, pipelaying, and dredging, which require the operator to prepare an environmental assessment including the risk to the prehistoric landscape. The fishing industry in Europe at present is not regulated or monitored in this way, although many fishermen voluntarily report regular retrieval of palaeontological materials.

(vii) No matter what laws or regulations are enacted, success depends on goodwill and collaboration between industrial operators, the environmental officials in commercial companies, regulatory authorities, professional academics, and amateur enthusiasts. Sports divers in many countries have provided important information, and have participated in underwater excavations of archaeological sites. The examples from the Solent, Danish waters, and the Dutch sector of the North Sea show what can be achieved.

(viii) Research to understand the role of the Continental Shelf in human evolution during the last million years is becoming a global topic. Study of submerged sites in Australia, Japan, throughout the Mediterranean, south Africa, the Caribbean, and North America provide the broad context for study of the European shelf.

Recommendations to English Heritage

(i) English Heritage, in cooperation with the other appropriate UK Home Country heritage agencies, should be encouraged to accept the responsibility to undertake the care of the submarine landscape out to the edge of the UK Continental Shelf, and should consider the necessary legal and administrative steps to do this.

(ii) English Heritage, in cooperation with the other appropriate UK Home Country heritage agencies, should continue to cooperate with other UK government regulatory bodies to ensure the protection of submarine prehistoric sites and the submerged prehistoric landscape, including consultation with DTI, DEFRA, CEFAS, and BGS.

(iii) English Heritage, in cooperation with the other appropriate UK Home Country heritage agencies, should act as the expert bodies of reference in regard to the DTI and offshore oil and gas, European directives, and other industrial liaison including advising other agencies regarding mitigation required to limit damage caused by offshore aggregate extraction, windfarm installations, pipelines, coastal engineering, and fisheries to the submarine prehistoric heritage.

Agreements

(i) The participants at the workshop agreed that there should be a continuing correspondence group, coordinated by Nic Flemming, Anders Fischer, and Geoff Bailey.

(ii) For the time being there is no need to establish a formal committee, or to try and create a subsidiary body affiliated with one of the larger existing archaeological organisations either at the UK or European level.

(iii) Informal correspondence, exchange of address lists, publications, etc, should be encouraged, leading to joint projects and joint applications for funding of projects.

(iv) Participants will continue to exchange information on projects, and on commercial activities where licenses for survey or exploitation have an impact on submarine prehistoric sites, or potential sites.

Recommendations in principle

(i) Legal regimes differ considerably in detail between the different national Continental Shelf sectors. Insofar as practicable, the implementation of European directives and the discharge of international treaty obligations should be done in such a way that professional groups can work together across lateral boundaries and median lines.

(ii) At present the joint collaboration of diving teams from different countries, or across Continental Shelf boundaries is difficult, and this is often due to different regulations regarding the training required by working scientists, different regulations relating to equipment which can be used, and different requirements for medical back-up on site. Mutual recognition of standards would increase the efficiency of joint research programmes.

(iii) Prehistoric archaeological sites can survive for many thousands of years after inundation, but experience shows that many known sites are being eroded, or are threatened by dredging and coastal engineering. An active policy is needed to investigate and determine the correct balance of research, modelling, exploration and discovery, mapping, excavation, and protection of sites, both legal and physical.

(iv) Marine and nautical archaeology have uncertain lines of funding in most countries, and submarine prehistoric research and the conservation of submarine prehistoric sites is as yet not an established discipline. Participants agreed that a more secure funding environment should be established if possible, combining academic and institutional programmes, statutory conservation policies, and funding from private organisations and trusts, as well as through collaboration with industry. Joint projects with participants from several countries should seek European funding.

(v) All offshore and coastal industries are required, at least in principle, to comply with national, European, and international obligations regarding the protection of submarine prehistoric sites and landscapes. From the point of view of conservation and research there is a great deal to be gained by collaborating with the marine industries so as to exploit the powerful technologies used. These technologies can help to prospect the archaeological potential of regions of the sea floor, and to recover artefacts, or geological and palaeontological samples. Industries should be encouraged to participate in joint projects through good communications, publications, and personal contacts.

Bibliography

Aaris-Sørensen, K, Petersen, K S, & Tauber, H, 1990 Danish Finds of Mammoth (*Mammuthus primigenius* (Blumenbach)), Stratigraphical position, dating and evidence of late Pleistocene environment, *Danmarks Geologiske Undersøgelse*, Serie **B14**, 1–44

Åkerlund, A, 1996 *Human responses to shore displacement: living by the sea in eastern middle Sweden during the Stone Age*, Riksantikvarieämbetet Arkeologiska Undersökninger Skrifter **16**. Stockholm: Studier Från uv Stockholm (Theses and paper in North European Archaeology, 16)

Alimen, M-H, 1975 Les isthmes Hispano-Marocain et Siculo-Tunisien aux temps Acheuléens, *L'Anthropologie*, **79**, 399–436

Allen, L C, & Gibbard, P L, 1993 Pleistocene evolution of the Solent River of Southern England, *Quaternary Science Reviews*, **12**, 503–28

Allen, M, & Gardener, J, 2000 *Our changing coast; an archaeological survey of Langstone Harbour, Hants*, CBA Res Rep **124**. York: Council for British Archaeology

Alphen, J S L J van, & Damoiseaux, M A, 1989 A geomorphological map of the Dutch shoreface and adjacent part of the continental shelf, *Geologie en Mijnbouw*, **68**, 433–43

Andersen, K, 1983 *Stenalderbebyggelsen i den Vestsjaellandske Åmosen*. Copenhagen: Fredningsstyrelsen

Andersen, S H, 1980 Tybrind Vig, Foreløbig meddelelse om en undersøisk stenalderboplads ved Lillebælt, *Antikvariske Studier*, **4**, 7–22

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

Andersen, S H, 1995 Coastal adaptation and marine exploitation in late Mesolithic Denmark – with special emphasis on the Limfjord region, in A Fischer (ed) 1995b, 41–66

Andrews, G, Barrett, J C, & Lewis, J S C, 2000 Interpretation not record: the practice of archaeology, *Antiquity*, **74**, 525–30

Anscher, T J ten, & Gehasse, E F, 1993 Neolithische en Vroege Bronstijd bewoning langs de benedenloop van de Overijsselse Vecht, in J H F Bloemers, W Groenman-Van Waateringe, & H A Heidinga (eds) *Voeten in de aarde; een kennismaking met de moderne Nederlandse archeologie*. Amsterdam: Amsterdam University Press, 25–44

Azzaroli, A, 1983 Quaternary mammals and the 'EndVillafranchian' dispersal event – a turning point in the history of Eurasia, *Palaeogeogr., Palaeoclimatol., Palaeoecol.*, **44**, 117–39

Bailey, G N (ed), 1997 *Klithi: Palaeolithic settlement and Quaternary landscapes in Northwest Greece*, 2 vols. Cambridge: McDonald Institute for Archaeological Research

Bailey, G N, & Craighead, A, 2003 Late Pleistocene and early Holocene coastal palaeoeconomies: a reconsideration of the molluscan evidence from Northern Spain, *Geoarchaeology: an International Journal*, **18**(2), 175–204

Bailey, G, & Milner, N J, 2002 Coastal hunters and gatherers and social evolution: marginal or central? *Before Farming: the Archaeology of Old World Hunter-Gatherers*, **3–4**(1), 1–15. Available: <http://waspjournals.com>

Bailey, G, & Parkington, J, 1988 *The Archaeology of Prehistoric Coastlines*. Cambridge: Cambridge University Press

Bang-Andersen, S, 1990 The Myrvatn Group, a Preboreal Find-Complex in Southwest Norway, in P M Vermeersch & P van Peer (eds) 1990, 215–26

Bang-Andersen, S, 2003 Southwest Norway at the Pleistocene/Holocene Transition: Landscape Development, Colonization, Site Types, Settlement Patterns, *Norwegian Archaeological Review*, **36**, 5–25

Barton, R N E, Roberts, A J, & Roe, D A (eds), 1991 *The Late Glacial in north-west Europe: human adaptation and environmental change at the end of the Pleistocene*, CBA Res Rep **77**. Oxford: Alden Press

Barton, R N E, 1992 *Hengistbury Head Dorset* vol 2: *The late Palaeolithic & Early Mesolithic Sites*, Oxford University Committee for Archaeology Monograph **34**. Oxford: Oxford University Press

Barton, R N E, Berridge, P J, Walker, M J C, & 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

Bates, M R, & Bates, C R, 2000 Multidisciplinary approaches to the geoarchaeological evaluation of deeply stratified

sediment sequences: examples from Pleistocene and Holocene deposits in southern England, UK, *Journal of Archaeological Science*, **27**(9), 845–58
Bednarick, R G, 2003 Seafaring in the Pleistocene, *Cambridge Archaeological Journal*, **13**, 41–66
Beets, D J, & Spek, A J F van der, 2000 The Holocene evolution of the barrier and the back-barrier basins of Belgium and the Netherlands as a function of late Weichselian morphology, relative sea-level rise and sediment supply, *Netherlands Journal of Geosciences/Geologie en Mijnbouw*, **79**, 3–16
Beets, D J, Roep, T B, & Westerhoff, W E, 1996 The Bergen inlet; closing history and related barrier propagation, *Mededelingen Rijks Geologische Dienst*, **57**, 97–133
Bjerck, H B, 1990 Mesolithic site types and settlement patterns at Vega, Northern Norway, *Acta Archaeologica*, **60**, 1–32
Bjerck, H B, 1995 The North Sea Continent and the pioneer settlement of Norway, in A Fischer (ed) 1995b, 131–44
Blackham, A M, Field, D, & Cowling, G, 1985 *The North Sea Environmental Guide*. Ledbury: Oilfield Publications Ltd
BMAPA & English Heritage, 2003, *Marine Aggregates Dredging and the Historic Environment: Guidance Note* British Marine Aggregates Producers Association and English Heritage: London
Boeskorov, G, 2001 Woolly rhino (*Coelodonta antiquitatis*) distribution in Northeast Asia, *Deinsea*, **8**, 15–20
Bokelmann, K, 1991 Some new thoughts on old data on humans and reindeer in the Ahrensburgian tunnel valley in Schleswig-Holstein, Germany, in N Barton, A J Roberts & D A Roe (eds) 1991, 72–81
Bonifay, M-F, 1996 The importance of mammalian faunas from the early middle Pleistocene of France, in C Turner (ed) *The early middle Pleistocene in Europe*. Rotterdam: Balkema, 255–62
Bonsall, C (ed), 1989 *The Mesolithic in Europe. Papers Presented at the Third International Symposium, Edinburgh 1985*. Edinburgh: John Donald
Bowdler, S, 1977 The coastal colonisation of Australia, in J Allen, J Golson & R Jones (eds) *Sunda and Sahul: Prehistoric studies in Southeast Asia, Melanesia and Australia*. London and New York: Academic Press, 205–46
Bratlund, B, 1991 A study of hunting lesions containing flint fragments on reindeer bones at Stellmoor, Schleswig-Holstein, Germany, in N Barton, A J Roberts & D A Roe (eds) 1991, 193–207
Bratlund, B, 1996 Archaeozoological Comments on Final Palaeolithic Frontiers in South Scandinavia, in L Larsson (ed) 1996, 23–33
Bree, P J H van, & Erdbrink, D P Bosscha, 1987 Fossil Phocidae in some Dutch collections (Mammalia, Carnivora), *Beaufortia*, **37**, 43–66
Brew, D S, Holt, T, Pye, K, & Newsham, R, 2000 Holocene sedimentary evolution and palaeocoastlines of the Fenland embayment, eastern England, in I Shennan & J E Andrews (eds) 2000 *Holocene land-ocean interaction and environmental change around the North Sea*. London: The Geological Society, 253–73
Bridger, J P, 1970 Some effects of the passage of a trawl over a seabed, ICES C M 1970/B:10, *Gear and Behaviour Comm*. Copenhagen International Council for Exploration of the Sea
Bridger, J P, 1972 Some observations on the penetration into the sea bed of tickler chains on a beamtrawl, ICES C M 1972/B:7, *Gear and Behaviour Comm.* Copenhagen International Council for Exploration of the Sea
Bryant, P J, 1995 Dating remains of grey whale of the Eastern North Atlantic, *Journal of Mammalogy*, **76** (3), 857–61
Bulten, E E B, Heijden, F J D van der, & Hamburg, T, 2002 *Prehistorische visweren en fuiken bij Emmeloord*. Bunschoten (ADC rapport 140). Bunschoten ADC
Burkitt, M C, 1932 A Maglemose Harpoon Dredged Up from the North Sea, *Man* **32**, 99
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*. British Geological Survey, UK Offshore Regional Report. London: HMSO
Cameron, T D J, Laban, C, & Schüttenhelm, R T E, 1984 *Quaternary geology*, BGS/RGD, Sheet 52°N-2°E, Flemish Bight 1:250.000 series
Cameron, T D J, Laban, C, & Schüttenhelm, R T E, 1989a Upper Pliocene and Lower Pleistocene stratigraphy in the Southern Bight of the North Sea, in J P Henriet, G de Moor & M de Batist (eds) *The Quaternary and Tertiary Geology of the Southern Bight, North Sea*. Ghent: BEON, 97–110
Cameron, T D J, Schüttenhelm, R T E, & Laban, C, 1989b Middle and Upper Pleistocene and Holocene stratigraphy in the southern North Sea between 52° and 54°N, 2° to 4° E, in J P Henriet, G de Moor & M de Batist (eds)

The Quaternary and Tertiary Geology of the Southern Bight, North Sea. Ghent: BEON, 119–135

Chapman, H, Fletcher, W, Fenwick, H, Lillie, M, & Thomas, G, 2000 The archaeological survey of the Hull valley, in R Van de Noort & S Ellis (eds), *Wetland heritage of the Hull valley, an archaeological survey.* Hull: Humber Wetlands Project, University of Hull, 105–74

Childe, V G, 1925 *The Dawn of European Civilization*. London: Kegan Paul

Christensen, C, Fischer, A, & Mathiassen, D R, 1997 The great sea rise in the Storebælt, in L Pedersen, A Fischer & B Aaby (eds) 1997, 45–54

Clark, J G D, 1932 *The Mesolithic Age in Britain*. Cambridge: Cambridge University Press

Clark, J G D, 1952 *Prehistoric Europe: the economic basis*. London: Methuen

Clottes, J, & Courtin, J, 1994 *The Cave beneath the Sea*. New York: Harry N Abrams

Clottes, J, Beltran, A, Courtin, J, & Cosquer, H, 1992 The Cosquer cave on Cape Morgiou, Marseilles, *Antiquity*, **66**, 583–98

Clutton-Brock, J, & Noe-Nygaard, N, 1990 New Osteological and C-Isotope Evidence on Mesolithic Dogs: Companions to Hunters and Fishers at Star Carr, Seamer Carr and Kongemose, *Journal of Archaeological Science*, **17**, 643–53

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

Coles, B, 1999 Doggerland's loss and the Neolithic, in B Coles, J Coles & M Schou Jørgensen (eds) *Bog bodies. Sacred sites and wetland archaeology.* Wetland Archaeology Research Project occasional paper **12**. Exeter: University of Exter, 51–7

Cziesla, E, 2000 Spatpalaolithische Widerhakenspitzen aus Brandenburg. Eine Forschungsgeschichte, *Archäologisches Korrespondenzblatt*, **30**, 173–86

Dahlin, H, Flemming, N C, Nittis, K, & Petersson, S (eds) 2004 *Building the European Capacity in Operational Oceanography, Proceedings of the third EuroGOOS Conference, Athens*, Elsevier Oceanography Series 69. Amsterdam: Elsevier

Dampier, W, 1697 *A New Voyage round the World*. London

Darwin, C, 1839 *Journal of Researches into the Natural History and Geology of the Countries Visited during the Voyage round the World of H M S 'Beagle' under command of Captain Fitz Roy, R N*. London: John Murray

Davidsen, K, 1983 Stenalderfund fra østersbanker ved Kølholm i Roskilde Fjord, *Antikvariske studier*, **6**, 127–36

de Groot, S J, 1973 De invloed van trawlen op de zeebodem, *Visserij*, **26**, 401–9

de Lumley, H, 1969 A paleolithic camp at Nice, *Scientific American*, **220** 42–50

de Vries, A J, 1990 Ovibos moschatus from the pleistocene of the Dutch Tidal Flats (Wadden shallows), *Cranium*, **7**(2), 78–82

Deacon, H J, & Shuurman, R, 1992 The origins of modern people: the evidence from Klasies River, in G Brauer & F H Smith (eds) *Continuity or Replacement: controversies in* Homo sapiens *evolution*. Rotterdam: Balkema, 121–9

Deeben, J, Hallewas, D P, & Maarleveld, T J, 2002 Predictive modelling in Archaeological Heritage Management of the Netherlands: the Indicative Map of Archaeological Values (2nd Generation), *Berichten ROB*, **45**, 9–56

Deinse, A B van, & Junge, G C A, 1937 Recent and older finds of the California grey whale in the Atlantic, *Temminckia*, **2**, 161–88

Dencker, J, & Jensen, O, 2000 Nye stenalderfund, Fløjstrup Skov, *Marinarkæologisk Nyhedsbrev fra Roskilde*, **13**, 18–19

Dencker, J, 2002 Storestrømmen og Guldborgsund, *Marinarkæologisk Nyhedsbrev fra Roskilde*, **19**, 8–9

Department for Culture Media and Sport, 2001 *The Historic Environment* A *Force for Our Future*. London: Department for Culture Media and Sport (www.culture.gov.uk)

Dinnin, M, & Lillie, M, 1995a The palaeoenvironmental survey of the meres of Holderness, in R Van de Noort & S Ellis (eds), *Wetland heritage of Holderness, an archaeological survey.* Hull: Humber Wetlands Project, University of Hull, 49–86

Dinnin, M, & Lillie, M, 1995b The palaeoenvironmental survey of southern Holderness and evidence for sea level change, in R Van de Noort, & S Ellis (eds), *Wetland heritage of Holderness, an archaeological survey.* Hull: Humber Wetlands Project, University of Hull, 87–121

Dix, J, 2000 Coastal Change, Climate and Instability. European Community L'Instrument Financière de L'Environnement (LIFE) Project, *Isle of Wight Centre for the Coastal Environment*, R McInnes & J Jakeways (eds), **2**, unpublished technical project report

Drees, M, 1986 Kritische kanttekeningen bij de naam 'Zwarte botten fauna', *Cranium*, **3**(2), 103–20

Dyer, K R, 1975 The buried channels of the 'Solent River', Southern England, *Proceedings of Geological Association of London*, **86**, 239–46

English Heritage, 2000 *Power of Place*, English Heritage Report

English Heritage, 2002 *Environmental Archaeology*, Centre for Archaeology Guidelines, English Heritage

English Heritage, 2003 *Coastal defence and the Historic Environment: English Heritage Guidance*. London: English Heritage

English Heritage/RCHME, 1996 *England's Coastal Heritage: a statement on the management of coastal archaeology.* London: English Heritage

Erdbrink, D P, 1967 New finds of fossil bears from the Netherlands, *Lutra*, **9**, 17–41

Erdbrink, D P, 1972 Two late pleistocene pinnipede remains in a private collection, *Lutra*, **14**, 23–32

Erdbrink, D P, Bosscha, 1981 Some more cave Lion remains, *Proc Kon Ned Akad v Wetensch*, **C84**, 21–43

Erdbrink, D P Bosscha, 1982a More fossil bear remains in some Dutch collections, *Scripta Geol*, **66**, 1–14

Erdbrink, D P Bosscha, 1982b Red Deer Keratic Artefacts in Dutch Collections, *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek*, **32**, 103–37

Erdbrink, D P Bosscha, 1983a More Fossil Material of *Ovibos* from the Low Countries and the North Sea, *Proc Kon Ned Akad van Wetensch*, **B86**, 39–53

Erdbrink, D P Bosscha, 1983b Sundry fossil bones of terrestrial mammals from the bottom of the North Sea, *Proc Kon Ned Akad v Wetensch*, **B86**, 427–48

Erdbrink, D P Bosscha, 1983c Eleven Bones: More Fossil Remains of Cave Lions and Cave Hyaenas from the North Sea Area, *Bijdragen tot Dierkunde*, **53**, 1–12

Erdbrink, D P Bosscha, 1983d Still more cave lion remains, *Proc Kon Ned Akad v Wetensch*, **B86**, 113–23

Erdbrink, D P Bosscha, 1985 Fossil wolves from the bottom of the North Sea, *Proc Kon Ned Akad v Wetensch*, **B88**, 381–96

Erdbrink, D P Bosscha, 1991 A selection of osteokeratic artefacts, *Proc Kon Ned Akad v Wetensch*, **B94**, 421–43

Erdbrink, D P Bosscha, & Bree, P J H van, 1986 Fossil Odobenidae in some Dutch Collections (Mammalia, Carnivora), *Beaufortia*, **36**, 13–33

Erdbrink, D P Bosscha, & Bree, P J H van, 1990 Further observations on fossil and subfossil odobenid material (Mammalia, Carnivora) from the North Sea, *Beaufortia*, **40**, 85–101

Eriksen, B V, & Bratlund, B (eds), 2002 *Recent studies in the Final Palaeolithic of the European Plain*. Højbjerg: Jutland Archaeological Society

Erlandson, J M, 2000 Anatomically modern humans, maritime voyaging, and the Pleistocene colonization of the Americas, in N G Jablonski (ed) *The First Americans: The Pleistocene Colonization of the New World*. San Francisco University of California Press

Erlandson, J M, 2001 The archaeology of aquatic adaptations: paradigms for a new millennium, *Journal of Archaeological Research*, **9**, 287–350

Ermolova, N M, 1978 *Theriofauna of the Angara river basin in the late Anthropogene*. Novosibirsk: Publishing House 'Nauka'

Essen, H van, & Mol, D, 1996 Plio-Pleistocene Proboscideans from the Southern Bight of the North Sea and the Eastern Scheldt (The Netherlands), in J Shoshani & P Tassy (eds) *The Proboscidea: Trends in Evolution and Paleoecology.* Oxford: Oxford University Press, 214–24

Essen, H van, 1986 Signalement van een diminutieve M3 suvan een wolharige mammoet, *Cranium*, **3**, 6–7

Essen, H van, 2003 Tooth Morphology of *Mammuthus meridionalis* from the southern bight of the North Sea and from several localities in the Netherlands, in J W F Reumer, J de Vos & D Mol (eds) Advances in Mammoth Research (Proceedings of the Second International Mammoth Conference, Rotterdam, May 16–20, 1999), *Deinsea*, **9**, 453–511

Evans, J G, 1975 *The environment of early man in the British Isles*. London: Book Club Associates

Everard, C E, 1954 The Solent River: a geomorphological study, *Transactions of the Institute of British Geographers*, **20**, 41–58

Fairbanks, R G, 1989 A 17,000-year glacio-eustatic sea level record: influence of glacial melting rates on the Younger Dryas event and deep-ocean circulation, *Nature*, **342**, 637–42

Firth, A, 2000 Development-led archaeology in coastal environments: investigation at Queenborough, Motney Hill and Gravesend in Kent, UK, in K Pye & J R L Allen (eds) *Coastal and estuarine environments: sedimentology, geomorphology and geoarchaeology.* London: Geological Society, 403–17

Firth, A, 2002 *Managing archaeology underwater: a theoretical, historical and comparative perspective on society and its submerged past*, BAR Int Ser **1055**. Oxford: British Archaeological Reports

Fischer, A, 1987 Stenalderbopladsen på Argusgrunden – en 7.000-årig bebyggelse på bunden af Smålandsfarvandet (English summary: The Stone-Age Site on the Argus Bank), *Fortidsminder og kulturhistorie, Antikvariske studier*, **8**, 11–58

Fischer, A, 1991 Pioneers in deglaciated landscapes: The expansion and adaptation of Late Palaeolithic societies in Southern Scandinavia, in N Barton, A J Roberts & D A Roe (eds) 1991, 100–21

Fischer, A (ed), 1992 *Stenalderbopladser ved Lindholm i Nyborg Fjord. En undervandsarkæologisk undersøgelse forud for anlæggelse af Storebæltsbroen*. Copenhagen: Skov- og Naturstyrelsen

Fischer, A, 1993a *Stenalderbopladser på bunden af Smålandsfarvandet. En teori afprøvet ved dykkerbesigtigelse* (English text: Stone Age settlements in the Småland Bight. A theory tested by diving). Hørsholm: Miljøministeriet, Skov- og Naturstyrelsen

Fischer, A, 1993b *Stenalderbopladser på bunden af Øresund. Afprøvning af en model. Del 1, det centrale Øresund*. Copenhagen: Miljøministeriet, Skov- og Naturstyrelsen

Fischer, A, 1994 Dating the early trapeze horizon. Radiocarbon dates from submerged settlements in Musholm Bay and Kalø Vig, Denmark, *Mesolithic Miscellany*, **15**(1), 1–7

Fischer, A, 1995a An entrance to the Mesolithic world below the ocean. Status of ten years' work on the Danish sea floor, in A Fischer (ed) 1995b, 371–84

Fischer, A (ed), 1995b *Man and Sea in the Mesolithic. Coastal settlement above and below present sea level, Proceedings of the International Symposium, Kalundborg, Denmark 1993*. Oxford: Oxbow

Fischer, A, 1996a At the border of human habitat. The Late Palaeolithic and Early Mesolithic in Scandinavia, in L Larson (ed) 1996, 157–76

Fischer A, 1996b Rødder og stubbe af havopslugte træer. *Marinarkæologiske forundersøgelser forud for etablering af en fast Øresundsforbindelse. Marinarkæologiske rekognosceringer efter fredede vrag og fortidsminder i højbrotraceet*. Copenhagen: Miljø- og Energiministeriet, Skov- og Naturstyrelsen, 41–3

Fischer, A, 1997a Drowned forests from the Stone Age, in L Pedersen, A Fischer & B Aaby (eds) 1997, 29–36

Fischer, A, 1997b Archaeologists in deep water, in L Pedersen, A Fischer & B Aaby (eds) 1997, 57–62

Fischer, A, 1997c People and the sea – settlement and fishing along the mesolithic coasts, in L Pedersen, A Fischer & B Aaby (eds), 1997, 63–77

Fischer, A, 1997d *Stenalderbopladser på bunden af Øresund. Afprøvning af en model. Del 2, det centrale og sydlige Øresund*. Copenhagen: Miljøministeriet, Skov- og Naturstyrelsen

Fischer, A, 2001 Mesolitiske bopladser på den danske havbund – udfordringer for forskning og forvaltning. (Summary Mesolithic settlements on the Danish sea floor –challenges to research and heritage management), in O L Jensen, S A Sørensen & K M Hansen (eds) 2001, 59–74

Fischer, A, 2003 Trapping up the rivers, trading across the sea, in L Larsson *et al* (eds) 2003, 393–401

Fischer, A, & Malm, T, 1997 The settlement in the submerged forest in Musholm Bay, in L Pedersen, A Fischer & B Aaby (eds) 1997, 78–86

Fischer, A, Olsen, J, Richards, M, Sveinbjörnsdottir, A E, & Bennike, P, in prep a, Coast-inland mobility and food composition in the Danish Mesolithic and Early Neolithic – evidence from stable isotopes values of humans and dogs.

Fischer A, Richards M, Bennike P, Robinson D, Olsen J, & Heinemeier J, in prep b, *The Mesolithic Menu. Food remains versus stable isotopes – evidence from a submerged Kongemosian settlement on the Argus Bank, Denmark*

Fischer, A, & Sørensen, S A, 1983 Stenalder på den danske havbund (English summary: Stone Age on the Danish Sea Floor), *Antikvariske studier*, **6**, 104–26

Fischer, A. 2004. Tissø og Åmoserne som trafikforbindelse og kultsted i stenalderen. *Historisk Samfund for Holboek Amt*, Årbog 2003: 27–44

Flemming, N C, 1983a Survival of submerged lithic and Bronze Age artefact sites: a review of case histories, in P M Masters & N C Flemming (eds) *Quaternary Coastlines and Marine Archaeology*. London & New York: Academic Press, 135–74

Flemming, N C, 1983b Preliminary geomorphological survey of an early Neolithic submerged site in the Sporadhes, N Aegean, in P M Masters & N C Flemming (eds) *Quaternary Coastlines and Marine Archaeology*. London & New York: Academic Press, 233–68

Flemming, N C, 1985 Ice Ages and human occupation of the Continental Shelf, *Oceanus*, **28** 1, 18–26

Flemming, N C, 1998 Archaeological evidence for vertical movement on the continental shelf during the Palaeolithic, Neolithic and Bronze Age periods, in I S Stewart & C Vita-Finzi (eds) *Coastal tectonics*, Geological Society Special Publication **146**. London: Geologocal Society, 129–46

Flemming, N C, 2002 The scope of Strategic Environmental Assessment of North Sea areas SEA3 and SEA2 in regard to prehistoric archaeological remains. Department of Trade and Industry, Strategic Assessment of Parts of the Central and Southern North Sea: SEA3, consultation document, technical report, CD ROM and website: www.offshore-sea. org.uk

Flemming, N C, 2003 The scope of Strategic Environmental Assessment of sea area SEA4 in regard to prehistoric archaeological remains, Department of Trade and Industry, Strategic Assessment of Parts of the Central and Southern North Sea: SEA4. Consultation Document. Technical Report. CD ROM and website www. offshore-sea.org.uk

Flemming, N, Bailey, G, Courtillot, V, King, G, Lambeck, K, Ryerson, F, & Vita-Finzi, C, 2003 Coastal and marine palaeoenvironments and human dispersal points across the Africa-Eurasia boundary, in C A Brebbia & T Gambin (eds) *The Maritime and Underwater Heritage*. Malta: Wessex Institute of Technology and the University of Malta, 61–74

Flerov, C C, 1967 On the origin of the mammalian fauna of Canada, in Hopkins, D M (ed), *The Bering Landbridge*. California: Stanford University Press, 271–80

Foley, R, 1981 Off-site archaeology: an alternative approach for the short-sited, in I Hodder (ed) *Pattern of the past, studied in honour of David Clarke*. Cambridge: Cambridge University Press, 157–83

Forsten, A, 1993 Size Decrease in late Pleistocene-Holocene Caballoid Horses (Genus Equus), Intra- or Interspecific Evolution? *Quaternary International*, **19**, 71–7

Fox, W D, 1862 How and when was the Isle of Wight separated from the mainland?, *The Geologist*, 452

Fulford, M, Champion, T, & Long, A, 1997 *England's Coastal Heritage: a survey for English Heritage and the RCHME*. London: EH/RCHME,

Galili, E, & Nir, Y, 1993 The submerged prepottery Neolithic water well of Atlit-Yam, northern Israel and its palaeoenvironmental implications, *The Holocene*, **3**, 265–70

Galili, E, Weinstein-Evron, M, Hershkovitz, I, Gopher, A, Kislev, M, Lernau, O, Kolska-Horwitz, L, & Lernau, H, 1993 Atlit-Yam: A prehistoric site on the sea floor off the Israeli coast, J*ournal of Field Archaeology*, **20**, 133–57

Galili, E, Weinstein-Evron, M, & Ronen, A, 1988 Holocene sea-level changes based on submerged archaeological sites off the northern Carmel coast in Israel, *Quaternary Research*, **29**, 36–42

Gamble, C, 1993 *Timewalkers: the prehistory of global colonization*. Stroud: Sutton

Gaspar, M D, 1998 Considerations of the *sambaquis* of the Brazilian coast, *Antiquity*, **72**, 592–615

Gaudzinski, S, 1999 The faunal record of the Lower and Middle Palaeolithic of Europe: remarks on human interference, in W Roebroeks & C Gamble (ed) *The Middle Palaeolithic occupation of Europe*. Leiden University of Leiden 215–34

Geddes, D S, Guilaine, J, & Monaco, A, 1983 Early Neolithic occupation of the submerged continental plateau of Roussillon (France), in P M Masters & N C Flemming (eds) *Quaternary Coastlines and Marine Archaeology*. London & New York: Academic Press, 175–87

Geel, B van, Bohncke, S J P, & Dee, H, 1981 A palaeoecological study of an upper Late Glacial and Holocene sequence from 'De Borchert', The Netherlands, *Rev Palaeobot Palynol* **31**, 367–448

Geel, B van, Coope, G R, & Hammen, T van der, 1989 Palaeoecology and stratigraphy of the late glacial type section at Usselo (the Netherlands), *Rev Palaeobot Palynol*, **60**, 25–129

Gell, A, 1985 How to read a map: remarks on the practical logic of navigation, *Man*, **20**, 271–86

Gibbard, P L, West, R G, Zagwijn, W H, Balson, P S, Burger, A W, Funnell, B M, Jeffery, D H, de Jong, J, Kolfschoten, T van, Lister A M, Meijer, T, Norton, P E P, Preece, R C, Rose, J, Stuart, A J, Whiteman, C A, & Zalasiewicz, J A, 1991 Early and early middle Pleistocene correlations in the southern North Sea Basin, *Quaternary Science Reviews*, **10**, 23–52

Glimmerveen, J, Mol, D, and Plicht, H van der, in press *The Pleistocene reindeer of the North Sea; initial palaeontological data and archaeological remarks*, *Proceedings of the Third International Mammoth Conference, 2003*

Glimmerveen, J, Mol, D, Post, K, Reumer, J W F, Plicht H van der, Vos, J de, Geel, B van, Reenen, G van, & Pals, J P, 2004 The North Sea project. The first palaeontological and archaeological results, this volume

Godwin, H, & Godwin, M E, 1933 British Maglemose Harpoon Sites, *Antiquity*, **7**, 36–48

Godwin, H, 1975 *The history of the British flora*. Cambridge: Cambridge University Press

Gosden, C, & Robertson, N, 1991 Models for Matenkupkum: interpreting a late Pleistocene site from southern New Ireland, Papua New Guinea, in J Allen & C Gosden (eds) *Report of the Lapita Homeland Project*, Occasional Papers in Prehistory **20**. Canberra: Department of Prehistory, Research School of Pacific Studies, the Australian National University, 20–45

Goudeswaard, B, 2000 Archaeological assessment within the Betuweroute Cargo Line Project, in K Evans & J Williams (eds) *Archaeological evaluation strategies in Belgium (Flanders and Wallonia), England, France and the Netherlands*. Maidstone: Kent County Council (Planarch)

Gramsch, B, 1973 *Das Mesolithikum im Flachland zwischen Elbe und Oder* Veröffentlichungen des Museums für Ur - und Fruhgeschicte, Berlin: Deutescher Verlag

Green, S, & Zvelebil, M, 1993 Interpreting Ireland's prehistoric landscape: the Bally Lough Archaeological Project, in P Boqueki (ed) *Case studies in European prehistory*. Princeton: CRC Press, 1–29

Grøn, O, 1989 General spatial behaviour in small dwellings. A preliminary study in ethnoarchaeology and social psychology, in C Bonsall (ed) *Proceedings of the Mesolithic in Europe III International Symposium*. Edinburgh: Edinburgh University Press, 99–105

Grøn, O, 1990 Studies in Settlement patterns and Submarine Bogs: Results and Strategy for Further Research, *Contributions to the Mesolithic in Europe, papers presented at the fourth International Symposium 'The Mesolithic in EUROPE', Leuven 1990*, in P M Vermeersh & P van der Peer (eds) 1990, 81–6

Grøn, O, & Skaarup, J, 1993 A submerged Mesolithic site and a 'boat burial' from Ærø, *Journal of Danish Archaeology*, **10**, 38–50

Grøn, O, 1995a *The Maglemose Culture. The reconstruction of the social organization of a mesolithic culture in Northern Europe*, BAR Int Ser 616. Oxford: British Archaeological Series

Grøn, O, 1995b Research in Stone Age sites at Submerged Shore Zones. Strategies and Experiences, in A Fischer (ed) 1995b, 403–8

Grøn, O, 2003 Mesolithic dwelling places in south Scandinavia: their definition and social interpretation, *Antiquity*, **77**, 685–708

Grøn, O, forthcoming, Strategies and methods used for location and excavation of the Ertebølle feature interpreted as the remains of a dwelling and description of the dwelling. *Møllegabet II– a submerged Mesolithic settlement in southern Denmark*

Grøn, O, Hoffmann, G, Brunn, H, & Schietzel, K, 1998 The Use of Acoustic High Resolution Sub-bottom Profilers for Geo-Archaeological Survey, Results from Jungshoved, Kerteminde Firth and Haithabu/Hedeby, in A Wesse (ed) *Studien zur Archäologie des Ostseeraumes. Von der Eisenzeit zum Mittelalter. Festschrift Für Michael Müller-Wille*. Neumünster: Wachholtz Verlag, 151–60

Grøn, O, & Kuznetsov, O, 2003 Ethno-archaeology among Evenkian forest hunters. Preliminary results and a different approach to reality! in L Larsson, H Kindgren, K Knutson, D Loeffler & A Åkerlund (eds) 2003, 216–21

Grønnow, B, 1987 Meiendorf and Stellmoor revisited An analysis of Late Palaeolithic reindeer exploitation, *Acta Archaeologica*, **56**, 131–66

Guérin, C, 1980 Les Rhinocerotidae (Mammalia, Perissodactyla) de Miocène supérieur au Pleistocène terminal en Europe occidentale. Comparaison avec les espèces actuelles, *Docum Lab Géol Lyon*, **79**, 1185

Hancock, G, 2002 *Underworld: the mysterious origins of civilisations*. London: Channel 4 Publications

Hansen, J Schou, 1981 *Naturgasprojektet og de marinarkæologiske forundersøgelser*. Copenhagen: Fredninsstyrelsen

Hardy, A, 1960 Was man more aquatic in the past? *New Scientist*, **7**, 642–5

Hartz, S, & Lübke, H, 1995 Erste Ansätze zur Prospektion submariner steinzeitlicher Küstenwohnplätze an der schleswig-holsteinischen Ostseeküste, *Archäologische Nachrichten aus Schleswig-Holstein*, **6**, 7–32

Haslett, S K, Davies, P, Davies, C F C, Margetts, A J, Scotney, K H, Thorpe, D J, &

Williams, H O 2001 The changing estuarine environment in relation to Holocene sea level and the archaeological implications, in S Rippon (ed) *Estuarine archaeology – the Severn and beyond*, Archaeology in the Severn Estuary **11**. Exeter: The Severn Estuary Levels Research Committee, 35–53

Head, R, 1995 The use of lithic material in prehistoric Holderness, in R Van de Noort, & S Ellis (eds) *Wetland heritage of Holderness, an archaeological survey.* Hull: Humber Wetlands Project, University of Hull, 311–22

Head, R, 1997 The use of lithic material in the Humberhead levels in prehistory, in R Van de Noort & S Ellis (eds) *Wetland heritage of the Humberhead Levels, an archaeological survey*, Hull: Humber Wetlands Project, University of Hull, 383–95

Head, R, Fenwick, H, Van de Noort, R, Dinnin, M, & Lillie, M, 1995a The meres and coastal survey, in R Van de Noort & S Ellis (eds) *Wetland heritage of Holderness, an archaeological survey.* Hull: Humber Wetlands Project, University of Hull, 163–240

Head, R, Fenwick, H, Van de Noort, R, Dinnin, M, & Lillie, M, 1995b The survey of southern Holderness, in R Van de Noort & S Ellis (eds) *Wetland heritage of Holderness, an archaeological survey.* Hull: Humber Wetlands Project, University of Hull, 241–310

Henshilwood, C S, Sealy, J S, Yates, R, Cruz-Uribe, K, Goldberg, P, Grine, F E, Klein, R G, Poggenpoel, C A, Niekerk, K van, & Watts, I, 2001 Blombos Cave, Southern Cape, South Africa: preliminary report on the 1992–99 excavations of the Middle Stone Age levels, *Journal of Archaeological Science*, **28**, 421–48

Hodson, F, & West, I M, 1972 Holocene Deposits of Fawley Hampshire, and the development of Southampton, Water, *Proceedings of the Geological Association*, **83**(4), 421–41

Hogestijn, J W H, & Peeters, J H M (eds), 2001 *De Mesolithische en Vroeg-Neolithische vindplaats Hoge Vaart-A27 (Flevoland)*. Amersfoort: ROB

Holt, J T, & Proctor, R, 2003 The Role of Advection in Determining the Temperature Structure of the Irish Sea, *Journal of Physical Oceanography*, **33**, 2288–306

Holt, J T, James, I D, & Jones, J E, 2001 An s-coordinate Model of the Northwest European Continental Shelf, Part 2 Seasonal currents and Tides, *Journal of Geophysical Research*, **106**(C7), 14035–53

Holt, M, 2003 Towards NOOS: the EuroGOOS NW Shelf Task Team 1996–2002, in H Dahlin, N C Flemming, K Nittis & S Petersson (eds) 2003, 461–5

Holt, M, Zhihong, L, & Osborne, J, 2003 Real-time forecast modelling for the NW European Shelf seas, in H Dahlin, N C Flemming, K Nittis & S Petersson (eds) 2003, 484–9

Hooijer, D A, 1957 Mammals and correlation of the 'Black Bones' of the Schelde Estuary with those of the Red Crag, *Geologie en Mijnbouw*, **19**, 255–6

Hooijer, D A, 1984a *Mammuthus meridionalis* (Nesti) and *M. armeniacus* (Falconer) from the North Sea, *Proc Kon Ned Akad v Wetensch*, **B87**, 335–59

Hooijer, D A, 1984b A Pleistocene ass *Equus asinus* L. subsp from the North Sea, *Lutra*, **27**, 193–202

Hooijer, D A, 1985 A further note on the fossil Anglo-Dutch ass from the North Sea, *Lutra*, **28**, 26–30

Hosfield, R T, 2001 The Lower Palaeolithic of the Solent: 'site' formation and interpretative frameworks, in F F Wenban-Smith & R T Hosfield (eds) *Palaeolithic archaeology of the Solent River*, Lithic Studies Society Occasional Paper **8**. London: Lithic Studies Society

Hoshimi K, & Akagi, S, 1994 On fossil *Odobenus rosmarus* found in the Bottom of the Sea of Japan off Shimane Prefecture, *Monogr Assoc Geol Collabr, Japan*, **43**, 53–63

HWTMA, 2000 Search, Annual Report 1999/2000, Hampshire and Wight Trust for Maritime Archaeology. Southampton: Hampshire and Wight Trust for Maritime Archaeology

HWTMA, 2000 The Story Beneath the Solent, Hampshire and Wight Trust for Maritime Archaeology. Southampton: Hampshire and Wight Trust for Maritime Archaeology

Iba, I, Matsui, A, & Nakajima, T, 1999 The Awazu shell midden: a submerged site at Lake Biwa, in H Kawanabe, G W Coulter & A C Roosevelt (eds) *Ancient Lakes: their Cultural and Biological Diversity.* Belgium: Kenobi, 135–45

Ingold, T, 1993 The temporality of the landscape, *World Archaeology*, **25**, 152–74

Jacobi, R M, 1976 Britain inside and outside Mesolithic Europe, *Proceedings of the Prehistoric Society*, **42**, 67–84

Jeffery, D H, Graham, C, Wright, S, Laban, C, & Schüttenhelm, R T E, 1988 *Sea bed sediments and Holocene geology*, BGS/RGD, Sheet 55°N-02°E. Dogger 1:250,000 series

Jensen, O L, Sørensen, S A, & Hansen, K M 2001 *Danmarks Jægerstenalder – Status og Perspektiver*. Hørsholm: Hørsholm Egns Museum

Kahlke, R-D, 1987 Die unterpleistozänen *Hippopotamus*-Reste von Untermaßfeld bei Meiningen (Bezirk Suhl, DDR), Ein Beitrag zur Forschungs-, Entwicklungs- und Verbreitungsgeschichte fossiler Hippopotamiden in Europa. Thesis Greifswald

Kenyon, N H, Belderson, R H, Stride, A H, & Johnson, M A, 1981 Offshore tidal sand-banks as indicators of net sand transport and as potential deposits, *Spec Publs Int Ass Sediment*, **5**, 257–68

Kerkhoff, N, & Mol, D, 1991 Inventarisatie van nederlandse vondsten van de muskusos, Ovibos moschatus (Zimmermann, 1780), *Cranium*, **8**(2), 65–70

Kindgren, H, 1995 Hensbacka-Hogen-Hornborgasjön: Early Mesolithic coastal and inland settlement in western Sweden, in A Fischer (ed) 1995b, 171–84

Kindgren, H, 2002 Tosskärr. Stenkyrka 94 revisited, in B V Eriksen & B Bratlund (eds) 2002, 49–60

Klein, R G, 1989 *The Human Career*. Chicago: Chicago University Press

Kolfschoten, T van, & Laban, C, 1995 Pleistocene terrestrial Mammal faunas from the North Sea Area, *Mededelingen Rijks Geologische Dienst*, **52**, 135–51

Kolfschoten, T van, & Meulen, A J van der, 1986 Villanyian and Biharian mammal faunas from the Netherlands, *Mem Soc Geol It*, **31**, 191–200

Kolfschoten, T van, & Turner, E, 1996 Early middle Pleistocene Mammalian Faunas from Kärlich and Miesenheim I and their biostratigraphical implications, in C Turner (ed) *The early middle Pleistocene in Europe*. Balkema: Rotterdam 227–53

Kolfschoten, T van, & Vervoort-Kerkhoff, Y, 1985 Nijlpaarden van Nederlandse bodem en uit de Noordzee, *Cranium*, **2**, 36–44

Kolfschoten, T van, & Vervoort-Kerkhoff, Y, 1986 *Eén miljoen jaar Rijnmond, Uitgave.*, Rotterdam: Diergaarde Blijdorp

Kolfschoten, T van, & Zijlstra, L, 1992 Het fossiele damhert (*Dama dama*) van Luttenberg, Overijssel, *Cranium*, **9**, 109–12

Kolfschoten, T van, 2001a Pleistocene Mammals from the Netherlands, *Bollettino della Società Paleontologica Italiana*, **40**, 209–15

Kortenbout van der Sluijs, G, 1970–71 Bones of Mammals from the Brown Bank area (North Sea), in L P Louwe Kooijmans, Mesolithic Bone and Antler Implements from the North Sea and from the Netherlands*, Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek*, **20–21**, 69–70

Kortenbout van der Sluijs, G, 1983 De resten van zoogdieren uit de Noordzee, *Grondboor en Hamer*, **37**, 4–7

Kunst, C E, 1937 Die Niederländischen Pleistozänen Hirsche, Thesis Leiden

Laban C, Cameron, T D J, and Schüttenhelm, R T E, 1984 Geologie van het kwartair in de zuidelijke bocht van de Noordzee, *Mededelingen van de Werkgroep voor Tertiaire en Kwartaire Geologie*, **21**, 139–54

Laban, C, & Lindeboom, H, 1990 Study 1: penetration depth of beamtrawl gear, in BEON Report 13, *Effects of beamtrawl fishery on the bottom fauna in the North Sea II - The 1990 studies*. Brussels: Belgische Geologische Dienst, 37–51

Laban, C, & Rijsdijk, K, 2002 De Rijn-Maasdelta's in de Noordzee, *Grondboor en Hamer*, **56** (3/4), 60–5

Lambeck, K, 1995 Late Devensian and Holocene shorelines of the British Isles and North Sea from models of glacio-hydro-isostatic rebound, *Journal of the Geological Society of London*, **152**, 437–48

Larsson, L (ed), 1996 *The Earliest Settlement of Scandinavia and its relationship with neighbouring areas*, Acta Archaeologica Lundensia series 8^0, Stockholm: Almquist and Wiksell, **24**

Larsson, L, 1983 Mesolithic settlement on the sea floor in the strait of Øresund, in P M Masters & N C Flemming (eds) 1983, 283–301

Larsson, L, Kindgreen, H, Knutsson, K, Loeffler, D, & Åkerlund, A (eds), 2003 *Mesolithic on the Move. Papers presented at the Sixth International Conference on the Mesolithic in Europe, Stockholm 2000*. Oxford: Oxbow

Lazarev, P A, 1977 *New find of woolly rhinoceros skeleton in Yakutia*, Proceedings of the Zoological Institute, Leningrad, **63**. Leningrad: Publishing House 'Nauka', 281–5

Lidén, K, Eriksson, G, Nordquist, B, Götherström, A, & Bendixen, E, 2004. "The wet and the wild followed by the dry and tame" – or did they occur at the same time? Diet in Mesolithic–Neolithic Southern Sweden. *Antiquity,* **78**, 23–33

Ligtermoet, L J, & Drees, M, 1986 Laat-Pleistocene en Holocene paardachtigen uit Nederlandse vindplaatsen en de Noordzee, *Cranium*, **3**, 86–91

Lillie, M, & Chapman, H P, 2001 Wetland archaeology on the edge: recent research into the nature of landscape development and settlement on the western margins of the European plain, in B Purdy (ed) *Enduring records – the environmental and cultural heritage of wetlands*. Oxford: Oxbow, 287–94

Lillie, M, & Gearey, B, 2000 The palaeoenvironmental survey of the Hull valley, and research at Routh Quarry, in R Van de Noort & S Ellis (eds) *Wetland heritage of the Hull valley, an archaeological survey.* Hull: Humber Wetlands Project, University of Hull, 31–86

Lillie, M, Gearey, B, & Chapman, H, 2003 Geoarchaeological evidence for Holocene landscape evolution in the Hull Valley, eastern England, UK. in A J Howard, M G Macklin & D G Passmore (eds) *Alluvial archaeology in Europe.* Lisse: Rotterdam. A A Balkema, pp. 69–79.

Lister, A M, & Essen, H van, 2003 *Mammuthus rumanus* (Ştefănescu), the earliest mammoth in Europe, in Petulescu & E Stiuca (eds), Bucharest: Romanian Academy. *Advances in Vertebrate Paleontology 'Hen to Panta'*, Institute of Speleology Emil Racovita: 47–52

Lister, A M, & Sher, A V, 2001 The Origin and Evolution of the Woolly Mammoth, *Science*, **294**, 1094–97

Lister, A M, 1993 'Gradualistic' Evolution: its Interpretation in Quaternary Large Mammal Species, *Quaternary International*, **19**, 77–85

Loader, R, Westmore I, & Tomalin, D, 1997 *Time and Tide; an archaeological survey of the Wootton-Quarr coast*. Newport: Isle of Wight County

Long, A J, & Tooley, M J, 1995 Holocene sea-level and crustal movements in Hampshire and Southeast England, United Kingdom, in *Holocene Cycles: Climate, Sea Levels and Sedimentation*, Journal of Coastal Research, Special Issue **17**, 299–310

Long, A J, Innes, J B, Kirby, J R, Lloyd, J M, Rutherford, M M, Shennan, I, & Tooley, M J, 1998 Holocene sea level change and coastal evolution in the Humber estuary, eastern England: an assessment of rapid coastal change, *The Holocene*, **8**, 229–47

Long, D, & Holmes, R, 2001 *Submarine landslides and the tsunami threat to Scotland*, Proceedings of the International Tsunami Symposium, Session 1, Seattle: International Union of Geology and Geophysics, 355–66

Long, D, Smith, D E, & Dawson, A G, 1989 A Holocene tsunami deposit in eastern Scotland, *Journal of Quaternary Science*, **4**, 61–6

Lourandos, H, 1997 *Continent of Hunter Gatherers: new perspectives in Australian prehistory.* Cambridge: Cambridge University Press

Louwe Kooijmans, L P, 1970–71 Mesolithic bone and antler implements from the North Sea and from the Netherlands, *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek, Jaargang* **20–21**, 27–73

Louwe Kooijmans, L P, 2001 *Archeologie in de Betuweroute. Hardinxveld-Giesendam Polderweg, Een mesolithisch jachtkamp in het rivierengebied (5500–5000 v.Chr)*, Rapportage Archeologische Monumentenzorg **83**. Amersfoort: Rijksdienst voort het oudherdkundig Bodemon dervock

Lubbock, Sir John, 1865 *Prehistoric Times as illustrated by Ancient Remains and the Manners and Customs of Modern Savages*. London: Williams & Norgate

Lübke, H, 2001 Eine hohlendretuschierte Klinge mit erhaltener Schaftung vom endmesolithischen Fundplatz Timmendorf-Nordmole, Wismarbucht, Mecklenberg-Vorpommern, *Nachrichtenblatt Arbeitskreis Unterwasserarchaologie*, **8**, 46–51

Lübke, H, 2002 Steinzeit in der Wismarbucht: ein Uberblick, *Nachrichtenblatt Arbeitskreis Unter-wasserarchaologie*, **9**, 75–87

Lübke, H, 2003 New Investigations on Submarine Stone Age Settlements in the Wismar Bay Area, in L Larsson *et al* (eds) 2003, 633–42

Luby, E M, & Gruber, M F, 1999 The dead must be fed: symbolic meanings of the shellmounds of the San Francisco Bay area, *Cambridge Archaeological Journal*, **9**, 95–108

Maarleveld, T J, 1994 Het ruime sop of wanneer de mens ging varen. *Spiegel Historiael Jrg*, **29**(7/8), 277–82

Maarleveld, T J, 1997 Nautical Archaeology in the Netherlands: Developments and Cultural Appraisal, in W J H Willems, H Kars & D P Hallewas (eds), *Archaeological Heritage Management in the Netherlands, Fifty Years State Service for Archaeological Investigations*, van Gurcum, Assen: ROB, Amersfoort 35–57

MacPhee, R D E, Tikhonov, A N, Mol, D, Marliave, C de, Plicht, H van der, Greenwood, A D, Flemming, C, and Agenbroad, L, 2002 Radiocarbon Chronologies and

Extinction Dynamics of the late Quaternary Mammalian Megafauna of the Taimyr Peninsula, Russian Federation, *Journal of Archaeological Science*, **29**, 1017–42

Makaske, B, Smeerdijk, D G van, Peeters, H, Mulder, J R, & Spek, T, 2003 Relative water-level rise in the Flevo lagoon (the Netherlands), 5300–2000 cal yr BC: an evaluation of new and existing basal peat time-depth data, *Netherlands Journal of Geosciences / Geologie & Mijnbouw*, 82–2

Malm, T, 1995 Excavating submerged Stone Age sites in Denmark – the Tybrind Vig example, in A Fischer (ed) 1995b, 385–96

Masters, P M, & Flemming, N C (eds) 1983 *Quaternary Coastlines and Marine archaeology: towards the prehistory of land bridges and continental shelves*. London & New York: Academic Press

Mathiassen, T, 1943 *Stenalderbopladser in Åmosen*, Nordiske Fortidsminder III, Bind 3, Hefte. Copenhagen: Gyldendal

McBurney, C B M, 1967 *The Haua Fteah (Cyrenaica) and the Stone Age of the South-East Mediterranean*. London: Cambridge University Press

McInnes, R, & Jakeways, J (eds), 2002 *Instability: planning and management: seeking sustainable solutions to ground movement problems*. Ventnor: Isle of Wight Centre for the Coastal Environment

Mellars, P, 1970 An antler harpoon-head of 'Obanian' affinities from Whitburn, County Durham, *Archaeologia Aeliana*, 4th series, **48**, 337–46

Merleau-Ponty, M, 1962 *The phenomenology of perception*. London: Routledge & Kegan Paul

Mithen, S, 1999 Hunter-gatherers of the Mesolithic, in J Hunter & I Ralston (eds) *The archaeology of Britain. An introduction from the Upper Palaeolithic to the Industrial Revolution*. London: Routledge, 35–57

Mithen, S, 2003 *After the Ice*. London: Weidenfeld & Nicholson

Mol, D, 1991 Het ijstijdlandschap van de zuidelijke Noordzee, *Grondboor en Hamer*, **45**, 9–13

Mol, D, Post, K, Reumer, J W F, Vos, J de, & Laban, C, 2003 Het Gat: preliminary note on a Bavelian fauna from the North Sea with possibly two mammoth species, in J W F Reumer, J de Vos & D Mol (eds) Advances in Mammoth Research (Proceedings of the Second International Mammoth Conference, Rotterdam, May 16–20, 1999, *Deinsea*, **9**, 253–66

Mol, D, Vos, J de, & Reumer, J W F, 1998 Extinct beaver *Trogontherium cuvieri* Fischer, 1809 (Mammalia, Rodentia, Castoridae) from the Deep Water Channel between England and The Netherlands, *Mededelingen Nederlands Instituut voor toegepaste Geowetenschappen TNO*, **60**, 193–98

Momber, G 2004 The inundated landscapes of the western Solent, this volume

Momber, G, 2000a Coastal Change, Climate and Instability. European Community L'Instrument Financière de L'Environnement (LIFE) Project, *Isle of Wight Centre for the Coastal Environment*, R McInnes, & J Jakeways (eds) 2000, unpublished technical report

Momber, G, 2000b Drowned and deserted: a submerged prehistoric landscape in the Solent, England, *The International Journal of Nautical Archaeology* **29.1**, 86–99

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

Momber, G, 2002 Instability: Archaeology in a Drowned Landscape, in R McInnes & J Jakeways (eds) 2002, 633–40

Morgan, E, 1982 *The Aquatic Ape*. London: Souvenir Press

Morgan, L H, 1878 *Ancient Society, or Researches in the Lines of Human Progress from Savagery through Barbarism to Civilization*. New York: Holt

Morrison, A, & Bonsall, C, 1989 The Early Post-Glacial Settlement of Scotland: a Review, in C Bonsall (ed) 1989, 134–42

Nordqvist, B, 1998 *A Study of the Mesolithic on the West Coast of Sweden, Including a case-study of coastal sites with organic remains from the Boreal and Early Atlantic periods*. Göteborg: Göteborgs Universitet, Institutionen för Arkeologi

Oppenheimer, S, 1998 *Eden in the East: the drowned continents of Southeast Asia*. London: Weidenfeld & Nicholson

Osborn, A J, 1977 Strandloopers, mermaids, and other fairy tales: ecological determinants of marine resource utilization — the Peruvian case, in L R Binford (ed) *For Theory Building in Archaeology.* New York: Academic Press, 157–205

Oxley, I, & O'Regan, D, 2001 *The Marine Archaeological Resource*, IFA Technical Paper **4**. Reading: Institute of Field Archaeologists

Oxley, I, 2004 Constructive conservation in England's waters, this volume

Pals, J P, Geel, B van, & Delfos, A, 1980 Paleoecological studies in the Klokkeweel bog near Hoogkarspel (prov. of Noord Holland), *Rev Palaeobot Palynol*, **30**, 371–418

Pedersen, L D, Fischer, A, & Aaby, B, 1997 *The Danish Storaebaelt since the Ice Age: Man, Sea and Forest*. Copenhagen: Storebaelt Publications

Pedersen, L, 1995 7000 years of fishing: stationary fishing structures in the Mesolithic and afterwards, in A Fischer (ed) 1995b, 75–86

Pedersen, L, 1997 They put fences in the sea, in L Pedersen, A Fischer, & B Aaby (eds) 1997, 124–43

Pederson, L, 1997 Settlement and subsistence in the late Mesolithic and early Neolithic, in L Pederson, A Fischer, & B Aaby (eds) 1997,109–15

Peeters, J H M, forthcoming a, The Mesolithic to early Neolithic occupation at the Hoge Vaart (Almere, the Netherlands): forager land-use dynamics in the context of a drowning landscape, in *Acts of the XIVth UISPP congress*, BAR Int Ser. Oxford

Peeters, J H M, forthcoming b, Sites, landscapes and uncertainty; on the modelling of the archaeological potential and the assessment of deep-buried Stone Age landscapes in the Flevoland polders (the Netherlands), in E Rensink & J H M Peeters (eds) *Preserving the early past. Investigation, selection and preservation of Palaeolithic and Mesolithic sites and landscapes*. Amersfoort: ROB

Peeters, J H M, forthcoming c, The forager's pendulum; Mesolithic-Neolithic land-use, landscape dynamics and the temporal resolution of predictive models (Proceedings of the expert meeting on predictive modelling in archaeological heritage management). Amersfoort: ROB

Peeters, J H M, Makaske, A, Mulder, J, Otte-Klomp, A, Smeerdijk, D van, Smit, S, & Spek, T, 2002 Elements for archaeological heritage management: exploring the archaeological potential of drowned Mesolithic and early Neolithic landscapes in Zuidelijk Flevoland, *Berichten ROB*, **45**, 83–125

Peters, F J C, & Peeters, J H M (eds), 2001 *De opgraving van de mesolithische en neolithische vindplaats Urk-E4 (Domineesweg, gemeente Urk)*. Amersfoort (RAM 93): ROB

Pitulko, V V, 2001 Terminal Pleistocene-Early Holocene occupation in northeast Asia and the Zhokhov assemblage, *Quaternary Science Review*, **20**, 267–75

Pitulko, V V, Nikolsky, P A, Girya, E Y, Basilyan, A E, Tumskoy, W E, Koulakov, S A, Astakhov, S N, Pavlova, E Y, & Anismimov, M A, 2004 The Yana RHS Site: Humans in the Arctic before the last glacial maximum, *Science*, **303**, 52–6

Posford Haskoning, 2003 Regional environmental assessment for aggregate extraction in the eastern English Channel. East Channel Association (www.eastchannel.info)

Post, K, & Kompanje, E J O, 1995 Late Pleistocene white whales *Delphinapterus leucas* from Dutch coastal waters, *Lutra*, **38** (2), 67–76

Post, K, 1992 Vondsten van fossiele zoogdierbeenderen uit de Noordelijke Noordzee, *Cranium*, **9**, 40–1

Post, K, 1998 De Nederlandse fossiele zeezoogdieren. Een overzicht, *Cranium*, **15**(2), 67–74

Post, K, 1999 Laat Pleistocene zeezoogdieren van de Nederlandse kustwateren, *Grondboor en Hamer* **53** (6), 126–30

Post, K, 2000 Everzwijnjagers?, *Cranium*, **17** (1), 13–14

Price, T D, 1995 Some perspectives on prehistoric coastal adaptations and those who study them, in A Fischer (ed) 1995b, 423–4

Proctor, R, & James, I D, 1996 A fine-resolution 3D model of the Southern North Sea, *Journal of Marine Systems*, **8**, 285–95

Prøsch-Danielsen, L, & Høgestøl, M, 1995 A coastal Ahrensburgian site found at galta, Rennesøy, Southwest Norway, in A Fischer (ed) 1995b, 123–30

Raban, A, 1983 Submerged prehistoric sites off the Mediterranean coast of Israel, in P M Masters & N C Flemming (eds) 1983, 215–32

Raemakers, D, 2003 Cutting a long story short? The process of neolithization in the Dutch delta re-examined, *Antiquity*, **77**, 740–8

Ran, E T H, 1990 Dynamics of vegetation and environment during the Middle Pleniglacial in the Dinkel Valley (The Netherlands), *Mededelingen Rijks Geologische Dienst*, **44–3**, 141–205, with enclosures 1–9

Reid, C, 1913 *Submerged Forests*. Cambridge: Cambridge University Press

Renouf, M A P, 1984 Northern hunter-fishers: an archaeological model, *World Archaeology*, **16**, 18–27

Reumer, J W F, Rook, L, Borg, K van der, Post, K, Mol, D, & Vos, J de, 2003 Late

Pleistocene survival of the saber-toothed cat *Homotherium* in NW Europe, *Journal of Vertebrate Paleontology*, **23** (1), 260–2

Riccardi, E, Chizzola, S, & Vicino, G, 1987 Considerazioni sul rilievo della parte immersa della caverna a mare di Bergeggi (SV), *Rivista di Studi Liguri*, Anno LII, 1–4, Bordighera, Forma Maris Antiqui, 403–11

Richards, M P, & Hedges, R E M, 1999 A Neolithic revolution? New evidence of diet in the British Neolithic, *Antiquity*, **73**, 891–7

Richards, M P, Pettitt, P B, Stiner, M C, & Trinkaus, E, 2001 Stable isotope evidence for increasing dietary breadth in the European mid-Upper Palaeolithic, *Proc Natl Acad Science USA* 98, **11**, 6528–32

Roberts, P, & Trow, S, 2002 *Taking to the Water: English Heritage's Initial Policy for the Management of Maritime Archaeology in England*. London: English Heritage

Roever, J P de, 1976 Excavations at the river dune sites S21–22. Swifterbant Contribution 4, *Helinium*, **16**, 209–21

Rowley-Conwy, P, 1983 Sedentary hunters: the Ertebølle example, in G N Bailey (ed) *Hunter-Gatherer Economy in Prehistory.* Cambridge: Cambridge University Press, 111–26

Rudgley, R, 1998 *Lost Civilisations of the Stone Age*. London: Century

Rust, A, 1937 *Das altsteinzeitliche Rentierjägerlager Meiendorf*. Neumünster: Karl Wacholtz

Rust, A, 1943 *Die Alt- und Mittelsteinzeitlichen Funde von Stellmoor.* Neumünster: Karl Wacholtz

Sauer, C O, 1962 Seashore: primitive home of man? *Proceedings of the American Philosophical Society*, **106**, 41–7

Saville, A, 2001 A Mesolithic barbed antler point from the foreshore of the Forth Estuary, near Carriden, Falkirk, Calatria, *The Journal of the Falkirk Local History Society*, **15**, 70–80

Scaife, R, 2000 Coastal Change, Climate and Instability, European Community L'Instrument Financière de L'Environnement (LIFE) Project, *Isle of Wight Centre for the Coastal Environment*, R McInnes, & J Jakeways (eds), **2** unpublished technical report

Schaminée, J H J, Weeda, E J, & Westhoff, V, 1995 De vegetatie van Nederland. Deel 2, *Plantengemeenschappen van wateren, moerassen en natte heiden*. Uppsala/ Leiden: Opulus Press

Schilling, H, 1997 The Korsør Nor site. The permanent dwelling place of a hunting and fishing people in life and death, in L Pedersen, A Fischer & B Aaby (eds) 1997, 93–8

Schmitt, L, 1995 The West Swedish Hensbacka: a maritime adaptation and a seasonal expression of the North-Central European Ahrensburgian?, in A Fischer (ed) 1995b, 161–70

Schulting, R J, & Richards, M P, 2002 Dogs, Ducks, Deer and Diet: New Stable Isotope Evidence on Early Mesolithic Dogs from the Vale of Pickering, Northeast England, *Journal of Archaeological Science*, **29**, 327–33

Scuvée, F, & Verague, J, 1988 Le gisement sous-marine du Paléolithique Moyen de l'anse de la Mondrée à Fermanville (Manche), Ministère des Affaires Culturelles. Authorisation No 001740, 1971. CHP Littus, BP 306 Cherbourg 50104

Sha, L P, 1990 Preservation potential of ebb-tidal delta and inlet systems in response to sea-level rise: examples from the Dutch Wadden Sea, in L P Sha (ed) *Sedimentological studies of the ebb-tidal deltas along the West Frisian Islands, the Netherlands*. Utrecht: SN

Shackleton, J C, Andel, T H van, & Runnels, C N, 1984 Coastal Palaeo-geography of the Central and Western Mediterranean during the last 125,000 years and its archaeological implications, *Journal of Field Archaeology*, **11**, 307–31

Shennan, I, & Andrews, J E (eds), 2000 *Holocene land-ocean interaction and environmental change around the North Sea*. London: The Geological Society

Shennan, I, Lambeck, K, Flather, R, Horton, B, McArthur, J, Innes, J, Lloyd, J, Rutherford, M, & Wingfield, R, 2000a Modelling western North Sea palaeogeographies and tidal changes during the Holocene, in I Shennan & J E Andrews (eds) 2000, 299–319

Shennan, I, Lambeck, K, Horton, B P, Innes, J, Lloyd, J, McArthur, J, & Rutherford, M, 2000b Holocene isostacy and relative sea level on the east coast of England, in I Shennan & J E Andrews (eds) 2000, 265–98

Simmons, I, 1996 *The Environmental Impact of Later Mesolithic Cultures*, Edinburgh: Edinburgh University Press, for the University of Durham

Skaarup, J, 1981 Lyster, *Skalk*, **6**, 10–11

Skaarup, J, 1983 Submarine stenalderbopladser i Det sydfyneske ohav (Submarine stone-age settlement sites in the South Funn archipelago), *Antikvariske studier*, **6**, 137–61

Skaarup, J, 1995 Stone-Age Burials in Boats, in O Crumlin-Pedersen & B Munch Thye (eds) *The Ship as Symbol in Prehistoric* *and Medieval Scandinavia*, Studies in Archaeology & History **1**. Copenhagen: The Danish National Museum, 51–8

Skaarup, J, forthcoming, Description of features and analysis, in *Møllegabet II – a submerged Mesolithic settlement in southern Denmark*

Skov- og Naturstyrelsen 1987 *Havbundsundersøgelser. Råstoffer og fredningsinteresser. Smålandsfarvandet*. Copenhagen: Skov- og Naturstyrelsen

Skov- og Naturstyrelsen, 1988 *Roskilde Fjord*. Hørsholm: Skov- og Naturstyrelsen

Skov- og Naturstyrelsen 1988 *Storebælt*. Hørsholm: Skov- og Naturstyrelsen

Skov- og Naturstyrelsen 1989 *Hornbæk*. Hørsholm: Skov- og Naturstyrelsen

Skov- og Naturstyrelsen 1991 *Samsø Sydøst*. Hørsholm: Skov- og Naturstyrelsen

Smed, P, 1987a Argus Grund – Feltundersøgelser 1984, *Fortidsminder og kulturhistorie, Antikvariske studier*, **8**, 124–33

Smed, P, 1987b *Undersøiske Fortidsminder – en registrering*. Havbundsundersøgelser, Arkæologi. Hørsholm: Skov- og Naturstyrelsen

Sørensen, S, 1996 *Kongemosekulturen i Sydskandinavien*. Egnsmuseet Færgegården, Jægerspris

Sparks, B, Momber, G, & Satchell, J (eds), 2001 *A Decade of Diving, Delving and Disseminating*, *Hampshire & Wight Trust for Maritime Archaeology, 1991–2001*. Southampton: Southampton Oceanography Centre

Spikins, P, 2000 GIS models of past vegetation: an example from northern England, 10,000–5000BP, *Journal of Archaeological Science*, **27**, 219–34

Stouthamer, E, 2001 *Holocene avulsions in the Rhine-Meuse delta*. Ultrecht: Netherlands Geographical Studies

Stringer, C B, Barton, R N E, & Finlayson, J C (eds), 2000 *Neanderthals on the Edge: papers from a conference marking the 150th anniversary of the Forbes' quarry discovery, Gibraltar*. Oxford: Oxbow

Stringer, C, 2000 Coasting out of Africa, *Nature*, **405**, 53–5

Stuart, A J, 1982 *Pleistocene Vertebrates in the British Isles*. London and New York: Longman

Sugihara, S, & Serizawa, C, 1957 *Shell Mounds of the Earliest Jomon Culture at Natsushima Kanagawa Pref, Japan*, Reports on the Research by the Faculty of Literature, Meiji University, Archaeology **2**. Tokyo: Meiji University

Taylor, D, 1995 New pollen data from the Keyingham valley, southern Holderness, in R Van de Noort & S Ellis (eds) *Wetland heritage of Holderness, an archaeological survey*. Hull: Humber Wetlands Project, University of Hull, 121–8

Thenius, E, 1962 Die Großsäugetiere des Pleistozäns von Mitteleuropa, *Zeitschr für Säugetierkunde*, **27**, 65–83

Thomas, J, 2003 Thought on the 'repacked' Neolithic revolution, *Antiquity*, **77**, 67–74

Tilley, C, 1994 *A phenomenology of landscape – places, paths and monuments*. Oxford: Berg

Timpany, S, 2002 The submerged forest at Goldcliff East, *Archaeology in the Severn Estuary 2002*, **13**, 37–9

Tomalin, D J, Loader R, & Scaife, R G, forthcoming, *Wootton Haven: Coastal and port archaeology in a dynamic environment*. London: English Heritage

Tomalin, D, 1993 Maritime archaeology as a coastal management issue, in *Proceedings on the Standing Conference on problems associated with the coastline; seminar on regional coastal groups, after the House of Commons Report*, SCOPAC : Isle of Wight Council, 93–112

Tomalin, D, 2000a Geomorphological evolution of the Solent Seaway and the severance of the Wight: A review, in M Collins & K Ansell (eds) *Solent Science - A Review*. Amsterdam: Elsevier, 9–20

Tomalin, D, 2000b Coastal Change, Climate and Instability. European Community L'Instrument Financière de L'Environnement (LIFE) Project. *Isle of Wight Centre for the Coastal Environment*, R McInnes, & J Jakeways (eds), **2** unpublished technical project report

Tooke, W H, 1908 Strandloopers and landstroopers, II, *African Monthly*, **4**, 544–53

Torre, D, Ficcarelli, G, Masini, F, Rook L, & Sala, B, 1992 Mammal dispersal events in the early Pleistocene of western Europe, *Courier Forsch-Inst Senckenberg*, **153**, 51–8

Velegrakis, A F, 2000 Geology, geomorphology and sediments of the Solent system, in M Collins & K Ansell (eds) *Solent Science – A Review*. Amsterdam: Elsevier, 21–44

Velegrakis, A F, Dix, J K, & Collins, M B, 1999 Late Quaternary evolution of the upper reaches of the Solent River, Southern England, based upon marine geophysical evidence, *Journal of the Geological Society*, **156**, 73–87

Verhart, L B M, 1988 Mesolithic barbed points and other implements from Europoort, the Netherlands, *Oudheidkundige Mededelingen uit het Rijksmuseum van Oudheden Leiden*, **68**, 145–94

Verhart, L B M, 1995 Fishing for the Mesolithic. The North Sea: a submerged Mesolithic landscape, in A Fischer (ed) 1995b, 291–302

Verhart, L B M, 2000a *Times fade away. The neolithization of the southern Netherlands in an anthropological and geographical perspective*, Archaeological Studies Leiden University **6**. Leiden: Leiden University

Verhart, L B M, 2000b The Function of Mesolithic Bone and Antler Points, *Anthropologie et Préhistoire*, **111**, 114–23

Verhart, L B M, 2001 De zee neemt, de zee geeft. Spectaculaire vondsten uit de Noordzee. *Westerheem*, **50**, 3, 102–8

Verhart, L, 2003 Mesolithic Economic and Social Change in the Southern Netherlands, in L Larsson, H Kindgren, K Knuttson, D Loeffler & A Åkerlund (eds) 2003, 442–50

Vermeersch, P M, & Peer, P van (eds), 1990 *Contributions to the Mesolithic in Europe*. Leuven: Leuven University Press

VervoortKerkhoff, Y, & Kolfschoten, T van, 1988 Pleistocene and Holocene mammalian faunas from the Maasvlakte near Rotterdam (the Netherlands), *Meded Werkgr Tert Kwart Geol*, **25**, 87–98

Waals, J D van der & Waterbolk, T, 1976 Excavations at Swifterbant; discovery, progress, aims and methods, Swifterbant Contribution 1, Helinium, **16**, 4

Waals, J D van der, 1977 Excavations at the natural levee sites S2, S3/5 and S4, Swifterbant Contribution 6, *Helinium*, **17**, 3–27

Walters, R C, Buffler, R T, Bruggemann, J J, Guillaume, M M M, Berhe, S M, Negassi, B, Libsekal, Y, Cheng, H, Edwards, R L, Gosel, R von, Neraudeau, D, & Gagnon, M, 2000 Early human occupation of the Red Sea coast of Eritrea during the Last Interglacial, *Nature*, **405**, 65–9

Wenban-Smith, F, 2002 *Palaeolithic and Mesolithic archaeology on the seabed*. Salisbury: Wessex Archaeology

Westerhoff, W E, Cleveringa, P, Meijer, T, Kolfschoten, T van, & Zagwijn, W H, 1998 The Lower Pleistocene fluvial (clay) deposits in the Maalbeek pit near Tegelen, the Neterlands, in T van Kolfschoten & P L Gibbard (eds) *The Dawn of Quarternary Proceedings of the SEQS EuroMam symposium 1996*, Mededelingen Nederlands Instituut voor Toegepaste Geowetenschappen TNO **60**. 35–70

Whallon, R, & Price, T D, 1976 Excavations at the river dune sites S11–13, Swifterbant Contribution 5, *Helinium*, **16**, 221–9

White, M J, & 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

Wilkinson, T, & Murphy, P, 1995 *Archaeology of the Essex Coast*,vol 1. *The Hullbridge Survey*. East Anglian Archaeology Report **71**. Chelmsford: Essex County Council

Wilkinson, T, & Murphy, P, in prep. *Archaeology of the Essex Coast*, vol 2. *Excavations at The Stumble*. East Anglian Archaeology. Zagwijn, W H, 1963 Pollen-analytic investigations in the Tiglian of the Netherlands, *Meded Geol Stichting*, NS**16**, 49–71

Zarins J, Al-Jawad Murad, A, & Al-Yish, K S, 1981 The Comprehensive Archaeological Survey Program, a, The second preliminary report on the southwestern province, *Atlal, the Journal of Saudi Arabian Archaeology*, **5**, 9–42

Zijlstra, L, 1991 Nieuw schedelfragment muskusos van de Noordzeebodem, *Cranium*, **8**(2), 59–61

Zvelebil, M, 1996 Farmers our ancestors and the identity of Europe, in P Graves-Brown, S Jones & C Gamble (eds) *Cultural Identity and Archaeology: the construction of European communities*. London: Routledge, 145–66

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