North Sea Prehistory Research and Management Framework (NSPRMF) 2009

Rijksdienst voor het Cultureel Erfgoed
Ministerie van Onderwijs, Cultuur en Wetenschap

ENGLISH HERITAGE

VLAAMS INSTITUUT voor het ONROEREND ERFGOED

university of groningen

Universiteit Leiden

Universiteit Utrecht

UNIVERSITY OF Southampton

UNIVERSITY OF EXETER

UNIVERSITY OF BIRMINGHAM

Rijksmuseum van Oudheden
NATIONAL MUSEUM OF ANTIQUITIES

CLUE

NATUUR HISTORISCH MUSEUM ROTTERDAM

Cefas

Wessex Archaeology

for MARITIME Archaeology

North Sea Prehistory Research and Management Framework (NSPRMF) 2009

Amersfoort, 2009

Contents

Summaries *5*
Summary *5*
Samenvatting *5*
Zusammenfassung *5*
Resumé *5*
Résumé *6*

Introduction *7*
Aim and background *7*
Document outline *8*

Section 1 General outline and context *9*
1.1 Scope *9*
1.2 Spatial developments *11*
1.3 Management embedding *12*

Section 2 Resource assessment *15*
2.1 Assessment focus *15*
2.2 Stratigraphic and chronological frameworks *15*
2.3 Landscape surfaces *19*
2.4 Palaeontological and palaeobotanical assemblages *21*
2.5 Archaeological assemblages *22*

Section 3 Research agenda and strategies *27*
Theme A: Stratigraphic and chronological frameworks *27*
Theme B: Palaeogeography and environment *28*
Theme C: Global perspectives on intercontinental hominin dispersals *29*
Theme D: Pleistocene hominin colonisations of northern Europe *29*
Theme E: Reoccupation of northern Europe after the Last Glacial Maximum (LGM) *29*
Theme F: Post-glacial land use dynamics in the context of a changing landscape *30*
Theme G: Representation of prehistoric hunter-gatherer communities and lifeways *30*
Strategies *31*
Priorities *31*

Section 4 Resource management agenda and strategies *33*
Theme H: Legislation and preservation *33*
Theme I: Assessment and data sharing *34*
Theme J: Public outreach *34*
Strategies *35*
Priorities *35*

References *37*

During the expert meeting held as part of the development of this document, Mr. Jan Meulmeester (far left) exhibited his collection of Middle Palaeolithic hand axes dredged up in UK waters near Great Yarmouth. The spectacular finds received considerable attention from the international media and were covered by National Geographic News and Science. Jan Meulmeester, Hanson Aggregates Marine Limited and the British Marine Aggregate Producers Association were awarded the British Archaeology Award ('Best Archaeological Discovery'), as an example of how cooperation between science, industry and heritage management can lead to discoveries that engage with the public's fascination with archaeology. (Photo: Rob Buiter).

Summaries

Summary

The submerged prehistoric landscapes of the North Sea, and the archaeological sites on them, represent a common European cultural heritage, but also one that is of world-wide significance. It is from the North Sea margin that the earliest evidence of a pre-modern human presence in northern Europe has been obtained; and the region was inhabited, and also served as a pathway for human migration, for many hundreds of thousands of years. This rich, and exceptionally well-preserved, archaeological resource is increasingly threatened by off-shore activities, including aggregate extraction, wind-farm construction, hydrocarbon exploitation and fishing, besides natural processes of erosion. It is certainly not immune from 21st century impacts. Due to effective collaboration with industry, combined with the requirements of the EU 'Strategic Environmental Assessment' and 'Environmental Impact Assessment' Directives, there is now a flood of new information. However, archaeologists now need to stand back, to consider how future research and management should be directed. This document is a first attempt towards that.

Samenvatting

De verdronken prehistorische landschappen van de Noordzee en de daarin aanwezige vindplaatsen vertegenwoordigen gemeenschappelijk, Europees cultureel erfgoed, dat bovendien van wereldwijde betekenis is. De vroegste sporen van menselijke aanwezigheid in noordelijke Europa zijn aangetroffen langs de 'randen' van de Noordzee. Het gebied was bewoond en diende bovendien als migratieroute gedurende vele honderdduizenden jaren. Dit rijke en goed geconserveerde archeologisch bodemarchief wordt in toenemende mate bedreigd door activiteiten in zee, waaronder zand- en grindwinning, de aanleg van windmolens en onderwaterinstallaties, de (schelpen)visserij, maar ook door natuurlijke erosie. Het is zeker niet immuun voor de invloed van de 21e eeuw. Door effectieve samenwerking met de industrie en in combinatie met de 'Strategic Environmental Assessment' en 'Environmental Impact Assessment' richtlijnen van de EU beschikken we thans over een schat aan nieuwe informatie. Archeologen moeten nu echter enige afstand nemen om na te denken over nieuwe richtingen voor onderzoek en erfgoedzorg. Dit document is een eerste stap in die richting.

Zusammenfassung

Die prehistorisichen Unterwasserlandschaften der Nordsee mit ihren archäologlischen Fundstellen representieren ein geminsames, europäisches Kuluturerbe, welches ebenso von weltweiter Bedeutung ist. Die frühsten Bewiese für prämoderne menschliche Präsenz in Nordeuropa stammen aus der Randzone der Nordsee; die Region war besiedelt und diente ausserdem für mehrere hunderttausend Jahre als Pfad für Völkerwanderungen. Diese reiche und aussergewöhnlich gut erhaltende archäologische Informationsquelle wird neben dem natürlichen Prozess der Erosion auch immer mehr durch menschliche Aktivitäten auf See bedroht wie beispielsweise durch Förderung von Sand und Kies, dem Bau von Windkraftanlagen, die Nutzung von Öl und Gas Vorkommen und Fischerei. Sie ist sicherlich nicht immun gegen den Einfluss des 21. Jahrhunderts. Durch die effektive Zumsammenarbeit mit der Industrie, kombiniert mit den Anforderungnen der EU 'Strategic Environmental Assessment' und 'Environmental Impact Assessment' Direktive, gibt es nun eine Flut von neuen Informationen. Allerdings müssen Archäologen jetzt inne halten und bedenken wie zukünftige Forschung und Management geleitet werden sollten. Diese Dokument ist eine erster Versuch in diese Richtung.

Resumé

Nordsøens druknede forhistoriske landskaber, med deres arkæologiske pladser, repræsenterer enfælles europæiske kulturarv, som er af international betydning. Det er i Nordsøens kantområder detidligste spor af forhistorisk menneskelig tilstedeværelse i Nordeuropa er fundet; regionen varbeboet og tjente som forbindelsesvej for de menneskelige kulturers bevægelser gennem mangehundredetusinde år. Denne rige og ekseptionelt velbevarede arkæologiske resource er i stigende grad under trussel fra off-shore aktiviteter indkluderende råstof- og olieudvinding, vindmøllebygning og fiskeri samt naturlige erosionsprocesser. Den er langt fra immun overfor det 21. århundredes aktiviteter. På grund af effektivt

samarbejde med industrien i kombination medEUs 'Strategic Environmental Assessment' og 'Environmental Impact Assessment' direktiver, er dernu en strøm af ny information. For arkæologien er der imidlertid behov for en grundig overvejelseaf, hvordan det fremtidige forskning- og bevaringsarbejde skal gennemføres. Dette dokument eret første forsøg på at opridse en afklaringsproces.

Résumé

Les paysages préhistoriques submergés dans la Mer du Nord et les sites qui y sont présents, représentent un patrimoine culturel commun européen d'importance mondiale. Les vestiges de la première présence humaine dans le Nord de l'Europe ont été découverts aux bordures de la Mer du Nord. Le terroir était habité et servait de route de migration pendant des centaines de millénaires. Ce patrimoine riche et exceptionellement bien conservé est de plus en plus menacé, par les activités en pleine mer, comme l'extraction de sable et de gravier, la construction de moulins à vent et des installations sous-marines, la pêche, mais aussi par l'érosion naturelle. Il n'est certainement pas immunisé contre l'influence du 21e siècle. Grâce à la collaboration avec l'industrie et en combination avec les directives 'Strategic Environmental Assessment' et 'Environmental Impact Assessment' de la UE, il y a maintenant un flot de nouvelles informations. Les archéologues doivent maintenant prendre un recul nécessaire pour réfléchir sur le futur de la recherche et la gestion. Ce document est une première étape vers cette direction.

Fig. 1 Vast quantities of Pleistocene mammal remains are trawled up by the fishing industry every year. The fossils are generally in perfect condition (the picture shows a mammoth skull with parts of the tusks still attached). Thanks to the close cooperation between fishermen and palaeontologists, this rich resource is now available for scientific research. (Photo: Persbureau Flakkee).

Introduction

Aim and background

The purpose of the North Sea Prehistory Research and Management Framework (NSPRMF) is to facilitate the large-scale systematic and interdisciplinary study and preservation (where possible) of a unique sedimentary and archaeological record of some two million years that is currently submerged beneath the waters of the southern North Sea. This is intended as a 'living document' and so further comments from colleagues will be noted, and incorporated into future versions.

The North Sea Basin has undergone many changes driven by climate change and, at times, it may have been the largest wetland environment in Europe and a major focus of population. For these reasons, in relation to the terrestrial archaeological record, its archaeology may not just be 'more of the same', but perhaps qualitatively different from what we know already. Furthermore, the spectacular finds of the last decade have shown the excellent quality of the remains of former plant and animal communities (including early humans) within the sedimentary sequence; and several studies have demonstrated the extensive survival of entire submerged landscapes. The area has enormous potential for studying the relationships between early humans and their landscapes, and plainly this is of world-wide significance.

The North Sea Basin is, however, economically important and is exploited for a wide variety of resources (Fig. 1). Most types of economic exploitation lead to disturbance of the sea floor and some of them cut deep into the seabed. In addition, natural erosion and sedimentation involve continuous alteration of the sea floor topography. Almost all of these anthropogenic and natural processes have adverse effects on the preservation of cultural heritage resources present on, and just below, the sea floor. As the North Sea is internationally recognised as being of exceptionally high scientific value for the understanding of prehistoric human behaviour and palaeoenvironmental change, surviving areas of submerged palaeolandscape surfaces are important cultural heritage assets that are under continuous threat. In order to reduce further and uncontrolled loss of valuable archaeological and palaeoenvironmental sources of information, there is need for an effective research and management approach. The NSPRMF is meant to provide this.

The recognition of the importance of the North Sea for prehistoric archaeology, and the awareness that steps had to be taken to cope with major research and management issues, resulted in a workshop hosted in London by English Heritage in May 2003 under the title "North Sea Submarine Prehistory and Relations with Industry".[1] The purpose of this workshop, which was attended by delegates from five countries bordering the North Sea, was to define the research potential of this area, (and immediately adjacent waters), for prehistoric archaeology, and to discuss ways of cooperating on research and conservation of prehistoric finds on the sea floor. Despite the valuable contributions to both the workshop and the subsequent publication, implementing the workshop's conclusions by setting the agenda and enhancing international cooperation in the field of research and heritage management proved problematic.

In October 2006 two meetings in Amersfoort and Rotterdam followed up the London workshop and brought together a small group of representatives from the United Kingdom and the Netherlands concerned with North Sea research and heritage management.[2] The main objectives of these meetings were to explore the possibilities of developing a joint approach to the research and management of the submerged prehistoric archaeology and landscapes of the southern North Sea Basin and to improve information exchange. In order to push things beyond the scope of *ad hoc* initiatives developed and driven by individuals it was agreed that a common framework could play an important role in the development of shared approaches to the issues involved.

One of the initiatives concerned the start of an electronic newsletter on North Sea Prehistory, the first issue of which was circulated early 2007. Another initiative involved developing a second workshop to bring together a wider, but still selected, group of researchers and heritage managers from the Netherlands and the United Kingdom. The expert meeting *Towards a North Sea Prehistory Research and Management Framework* hosted by the National Service for Archaeology, Cultural Landscape and Built Heritage (now Cultural Heritage Agency) in Amersfoort, was held in March 2008. Its purpose

was to provide an update of the issues addressed at the London workshop, focusing on the southern North Sea Basin, as a basis for the drafting of the NSPRMF.

The overarching aim of the NSPRMF is to improve recognition of the international significance of the southern North Sea Basin for research on early humans in their landscapes. It is meant to encourage carefully developed and targeted research in the context of development-led and research-driven projects and programmes. It is also intended to underpin the development of conservation strategies adapted to the specific characteristics of this record. The framework is explicitly not meant to replace existing frameworks – generally more restricted in their geographical and/or chronological scope – nor to be prescriptive or over-regulatory.[3] In practical terms, the focus of the NSPRMF is to:

- maximize the return of archaeological information arising from spatial and economic developments;
- stimulate the study of archaeologically relevant deposits and materials in order to expand knowledge on past human landscape use and conservation of submerged cultural heritage;
- stimulate public understanding and awareness of the past, and to foster a shared sense of responsibility among developers, decision makers and scientists;
- allow heritage management judgement, consultancy and decisions to be firmly based on an internationally recognised and scientifically accepted set of resource assessments and research agenda.

Document outline

In this framework a distinction is made between research and management. However, the purpose of the NSPRMF is to harmonize the two, so as to create a favourable context for generating scientific knowledge on the prehistory of the southern North Sea and to enable management approaches that effectively tie in with scientific goals. The framework is organized in four sections:

- Section 1 – general outline and context
- Section 2 – resource assessment
- Section 3 – research agenda and strategies
- Section 4 – resource management agenda and strategies

Section 1 addresses the scope (in terms of chronology, geography and scale) of the NSPRMF and provides brief outlines of current spatial developments and how cultural heritage management is embedded in them. *Section 2* summarises the current state of knowledge and focuses on the archaeological understanding of the area in the broader context of research on early prehistoric landscape use, thus permitting the identification of gaps in the current state of knowledge and definition of research potential. In *Section 3* research themes and questions that are believed to be relevant to the area are presented, particularly to address identified knowledge gaps. Priorities, methods and initiatives addressing the agenda are defined in the form of a strategy. *Section 4* focuses on matching research needs to anticipated developments and provides a structure to link the research agenda with unanticipated developments. An active approach aiming at *in situ* conservation of valuable 'sites' and larger palaeolandscape zones is also presented.

Notes

1 Flemming 2004.

2 Nic Flemming, Peter Murphy, Peter Stassen, Andrea Otte, Hans Peeters, Jan Glimmerveen, Dick Mol and Jelle Reumer.

3 In the UK, several related research (and conservation) frameworks exist (e.g. Brown & Glazebrook 2000; Darvill 2005; Glazebrook 1997; Pettitt, Gamble & Last 2008; Williams & Brown 1997). Also see Wenban-Smith (2003). In the Netherlands, the national research agenda NOaA (Nationale Onderzoeksagenda Archeologie; www.noaa.nl) covers the entire range of archaeological periods. Deeben et al. (2006) cover early Prehistory. In Belgium, the national research agenda ('Onderzoeksbalans') addresses the importance of research potential of the North Sea for palaeogeographical reconstructions and Prehistory (see e.g. Pieters *et al.* in press).

Section 1 General outline and context

1.1 Scope

The *chronological* scope of the NSPRMF specifically refers to prehistory and does not consider the historic maritime heritage. The temporal extent is primarily defined by the occupation history of the British Isles and the European continent. The earliest hominin presence recorded in British Isles, from a site at Pakefield in Suffolk, is thought to date to *c.*700 Kyr.[4] No comparably early sites have been reported from the North West European continent so far: Germany's oldest site Schöningen is considered to date from *c.*400 Kyr). However, early hominid remains from Dmanisi (Republic of Georgia) at the 'Gates of Europe' push back human colonization to 1.7 Myr in the Eurasian region, while Atapuerca in northern Spain is dated to 1.2 Myr. There might, therefore, have been colonization of North West Europe earlier than 700 Kyr. For this reason the NSPRMF extends back to 2 Myr.[5]

The upper chronological limit of the NSPRMF is primarily defined by the Holocene inundation of what are today the shallowest parts of the North Sea between the British Isles and the Netherlands coastlines. This involved submergence of the land-mass of 'Doggerland' and the drowning of the lower valleys of major rivers such as Thames, Meuse and Rhine. In the southern North Sea, the inundation of the lowest areas started approximately 13.000 years ago, during the Late Palaeolithic, within the Allerød interstadial. Marine transgression extended both from the north, via the North Sea, and from the southwest along the English Channel (or La Manche) to the Straits of Dover. By 7500 years ago during the Early Atlantic, the southern North Sea had reached more or less its present extent, while the Southern Bight and northern North Sea were fully connected.[6] Offshore Mesolithic finds are relatively abundant. Neolithic use of the sea is almost impossible to target in terms of archaeological 'site' prediction and prospection, yet is an issue to include in the scope of NSPRMF.[7] The shallow, transgressing North Sea must have been a major element in the 'landscape' as perceived by prehistoric people living around it. Furthermore, uncertainties about Holocene sea level fluctuations and past elevations of Brown Bank mean that the possible existence of accessible, and maybe habitable, land in this area cannot be excluded. North Sea islands may have played a specific role in Middle Neolithic landscapes and seascapes.

In a *geographical* sense, the NSPRMF particularly refers to the southern North Sea and covers the Dutch and Belgian sections of the Continental Shelf and adjacent part of the UK section, including the Straits of Dover and extending to the English Channel (Fig. 2).[8] Geologically, this area covers both the southern shoulder and the Pleistocene sedimentary basin of the North Sea. To the southwest, outside the tectonically subsiding North Sea Basin, flint-bearing chalk, of later Cretaceous age, outcrops along the coasts of East Anglia and Kent, in England, or lies at shallow depth buried by relative thin younger deposits. Pleistocene rivers draining this area transported flint-bearing gravels. To the northwest chalk is also present, and the sea floor substrate is a mixture of fluvial sands

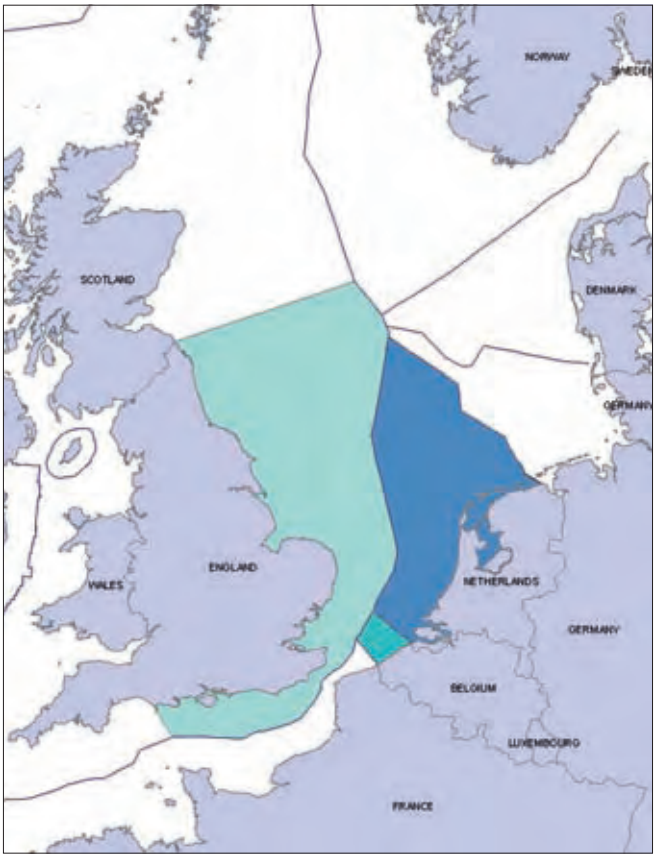


Fig. 2 Geographical scope of the NSPRMF.

deposited by the Rhine and North German rivers with outlets to the North Sea. These deposits were eroded, re-worked and partly re-deposited during the main Pleistocene glacial stages: the Anglian/Elsterian, Wolstonian/Saalian, and Devensian/Weichselian. A major fault zone separates the subsiding basin from its south-western shoulder, running southeast-northwest from the south-western Netherlands to the area of the Outer Silver Pit off the east of England.

Over the last 2 Myr the North Sea region has undergone continuous and dynamic landscape change, including some major changes related to repeated glaciation and opening of the Dover Straits. Glacial to interglacial climatic cycles have largely created the present submerged and terrestrial landscapes. Over this time the region has been inhabited by at least three hominin species: *Homo heidelbergensis*, *Homo neanderthalensis* and *Homo sapiens*. We must be aware constantly that modern day frontiers and mapped land masses condition our thinking about the North Sea as the 'corridor' connecting the British Isles to the Continent, but it is necessary to discount that when thinking about early prehistory. At times, the North Sea Basin would have provided an attractive living space. The archaeological evidence obtained so far (see Section 2) indicates that the North Sea Basin played a significant role in the cultural geography of prehistoric people. It was not merely a transitional zone or a route.

In terms of *scale*, the scope of the NSPRMF is first and foremost at the landscape level, and hence refers to the palaeoenvironmental, including palaeontological, importance of the North Sea. This does not exclude research at the level of specific archaeological 'sites', nor does it deny the importance of 'sites' as major sources of information. However, it emphasises the need to relate specific locations to the larger North Sea area. In the context of the NSPRMF, landscape archaeology is about humans using and transforming a dynamic environment. This was structured and given meaning in the human mind within a spatio-temporally dynamic context of social, economic, ideological, cosmological and historical relationships. In a landscape approach to archaeology, there is a need to identify, define and interpret the spatial and temporal relationships between manifestations of human activity and environmental dynamics. In this context, it must be underlined that manifestations of human activity are not confined to what archaeologists tend traditionally to make their subject of study, ('sites' and artefacts); but that these include *all* types of information that can inform us about how landscapes were used by hominins. There is other information unrelated to 'sites', such as that derived from palynological studies, charcoal distributions, and even archaeologically 'empty' space, that is equally relevant in this respect.

In addition, it should be stressed that the present sea-bed, as evidenced by bathymetry, does not correspond directly to any pre-existing landscape. Large parts of the North Sea floor as we see it now, reflect sediment re-working by waves and tidal currents over the last 7000 years. The resulting sheet of superficial deposits covers the Pleistocene to earlier Holocene landscapes in many places; and past landscape surfaces have been eroded at many others. Understanding archaeological landscapes in terms of their physical characteristics and human landscape use involves the construction of models which define the temporal and spatial relationships between palaeolandscape information and knowledge of prehistoric human behaviour at multiple scale levels from a dynamic perspective. Characterization of the archaeological landscape and

Fig. 3 'Mammoth-sized' dredgers in action for land reclamation for the extension of the Rotterdam harbour. (Photo: Klaas Post).

definition of the information potential of the modern day North Sea Basin for research on palaeolandscapes and prehistoric landscape use underpins the development of suitable heritage management approaches.

1.2 Spatial developments

The southern North Sea is a highly dynamic environment of major economic significance to the countries that surround it. The economic importance of the area is expressed through the scale of the fishing industry, aggregate extraction and energy resource extraction – both hydrocarbon-based and renewable – as well as offshore and coastal construction works such as pipelines and cables, and coastal risk management schemes. The exploitation of resources and spatial developments is to some extent predictable, but will change through time. It will therefore have changing impacts on heritage resources in the area and will provide new threats and opportunities for research and management. Along with anthropogenic effects on the preservation of the prehistoric heritage, natural processes have to be considered as part of the dynamics in the North Sea environment.

Threats to the preservation of the prehistoric heritage in the southern North Sea are numerous, yet at variable scale. Aggregate extraction, primarily of sand and gravel has a direct and major impact on the stratigraphic integrity and potential archaeological contexts (Fig. 3). On a yearly basis large volumes of aggregates are extracted.[9] Disturbance is not confined to near-surface layers and can reach to a depth of many metres below the sea-bed. Sand and gravel is extracted not only for onshore construction works, but also for construction of harbours, artificial islands and projected new airports, as well as for coastal risk management purposes. Furthermore, capital and maintenance dredging for new and existing navigation channels involves large scale disturbance.
Fishing by means of bottom trawling and beam trawling[10] has an impact confined to the uppermost surface of the sea floor; although beam trawling 'ploughs' the sea floor superficially it progressively leads to erosion of near-surface deposits of archaeological and palaeoecological significance. Near-surface deposits are, however, particularly vulnerable to natural erosion. In general unstratified artefacts and faunal remains out of context, recovered from trawl nets, are the evidence for this. Energy resource extraction involves a range of activities, such as cabling, the construction of pipelines and foundations for platforms and wind turbines, with variable impact on the sea bed. Even though many activities have localised effects, there may be wider secondary impacts, such as scouring over large surfaces as a result of altering hydrodynamics and accretion of sandbanks. Besides anthropogenic impacts, changing sediment dynamics related to climate change and consequent coastal change are unpredictable, but are unlikely to be benign in terms of the conservation of the submerged prehistoric cultural heritage.

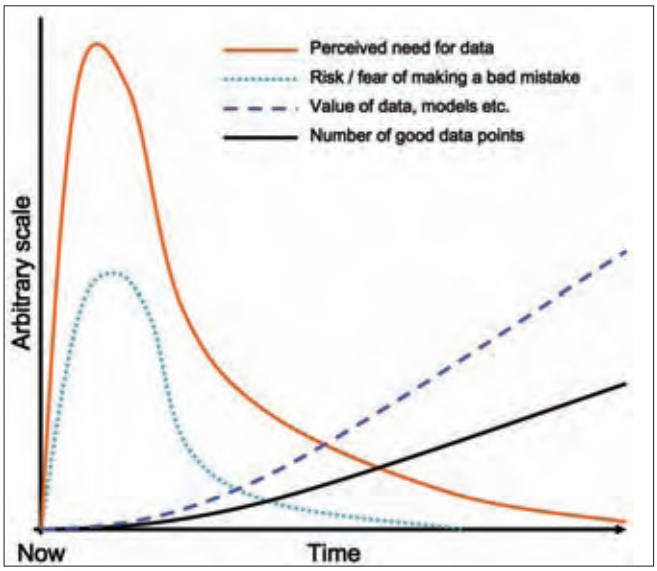


Fig. 4 Schematic representation of the relationship between scientific knowledge and decision making.

Opportunities for research and management represent the other side of the coin. Economic activities can be destructive, and there is a lack of sufficient field data to underpin decisions about offshore heritage management (Fig. 4). We are faced with the absence of a well-established body of firm data on which to build theories and develop predictive models on the nature, quality and spatio-temporal distribution of the prehistoric submerged heritage in the area. Hence, there is no sensible basis for making decisions at the interface of economic activity and heritage management in certain areas. Paradoxically, use can be made of economic activities, especially beam trawling and aggregate extraction, to collect the data needed and fill the fundamental gaps in our knowledge, Targeted actions, for example surveys undertaken to comply with the EU *Strategic Environmental Assessment* (SEA)[11] and *Environmental Impact Assessment* (EIA) Directives (see below) can be focused at zones of potential interest. Similarly, acoustic sub-bottom profiling and 3-D seismic surveys conducted in support of many industries provide vital information about palaeolandscapes now buried by marine sediments.
Besides obtaining data by these means, and from a research perspective, the risk of damaging *in situ* contexts through properly resourced scientific research must surely be accepted in the interest of creating a baseline for better informed decision-making later. In the 21st century we regret the damage done by some 19th century and earlier investigators to some types of terrestrial prehistoric sites, (especially to cave and burial mound deposits), but the fact remains that, without those interventions, the study of "*Pre-History*" could scarcely have begun. We should see ourselves as being at a similar stage of investigation for submerged prehistory, equipped with inadequate techniques, just as they were: but this time around we can do it knowingly and, one hopes, responsibly. With an increasing 'value' of data, models, deductions and

interpretations resulting from an increasing number of good data points, the currently perceived need for data and risk/fear of making bad mistakes will decrease over time (Fig. 4).

1.3 Management embedding

The area covered by the NSPRMF is subject to a range of regulations and legislation at national and international level. The cross-border focus of the framework requires this complex setting to be taken in account, as it has its drawbacks on research and heritage management in particular. This complexity is due to differential jurisdiction applying to territorial waters and the continental shelf, as well as legislation and regulation being spread over different areas of Government.

The *need* for management of our archaeological heritage arises from the notion that this heritage serves as our collective memory and is an indispensable source for reconstructing the history of mankind, but at the same time is vulnerable and finite. In Europe this realisation has led to the drafting of the *Convention on the Protection of the Archaeological Heritage*, better known as the Valletta Convention.[12] The convention acknowledges that the archaeological resource is threatened by the increasing number of spatial developments, natural threats such as erosion and climate change, clandestine excavations and a lack of public awareness. It encourages States to take responsibility and introduce measures to protect the archaeological heritage. Article 5 of the convention has been most influential. It prescribes the integrated conservation of archaeological heritage: the embedding of the archaeological considerations within planning of schemes and projects, to help ensure that archaeological sites are detected in time, and preserved *in situ* when possible or otherwise are properly excavated. Funding for these measures should be provided within the budget relating to development schemes. The convention has been widely adopted and its principles form the basis of archaeological heritage management policies and cultural heritage laws in most European countries.

All countries adjoining the North Sea have heritage *legislation* to protect and manage the archaeological resource. Although legislation differs from one country to another, generally speaking it provides for protection of archaeological sites, regulation of destructive activities through licensing, and supervision of the quality of archaeological research. In some cases there is a single legislative system that covers all archaeological sites both land and sea (e.g. the Dutch Monuments Act 1988), while in others there is separate legislation for the seabed archaeology with emphasis on shipwrecks and much less regard for the prehistoric component.[13] Besides the sectoral heritage legislation most countries also have spatial and environmental legislation and *policies* that seek to integrate archaeology within planning schemes and other developments that directly or indirectly affect the archaeological resource. In practice, this often means that in order to get a licence or planning consent for a specific activity the results of a preliminary archaeological study and assessment have to be provided. At EU level, the SEA Directive is of importance here, as it is to ensure that environmental consequences of certain plans and programmes are identified and assessed during their preparation and before their adoption and also applies to the marine environment.[14] Significantly, effects should not only be assessed relative to environmental factors (e.g. biodiversity, population, human health, flora, fauna, soil, water, air, climatic factors, cultural heritage) in isolation, but also relative to the interrelations between them.

Plainly, during the development of a cross-border approach on research and management of the prehistoric landscape of the North Sea, differences in legislation, policies and even heritage management philosophies have to be dealt with. To make matters even more complex, the area covered by the NSPRMF also includes a large area beyond national jurisdiction. The legislative regime for this area is determined by the *United Nations Convention on the Law of the Sea* (UNCLOS)[15], intended first and foremost to regulate the use of the sea and its natural resources. The convention itself is somewhat limited in terms of conservation of cultural heritage.[16] To supplement this, the *Convention for the Protection of Underwater Cultural Heritage* was drafted in 2001. This convention came into force in January 2009,[17] and has already triggered initiatives geared at the management of the underwater heritage.[18] In addition, the *European Landscape Convention* provides for protection of significant landscapes, including some marine areas.[19]

According to UNCLOS the first twelve nautical miles from the coastline are defined as territorial waters and are under total sovereignty of the coastal state. National heritage legislation may be applied fully out to this limit.[20] Potentially, UNCLOS also makes provision for archaeological and historical objects found in the next contiguous twelve nautical miles.[21]

Beyond territorial waters and the contiguous zone there is only very limited provision for protection of the archaeological heritage. Coastal states are allowed to regulate the use of the sea, the exploitation of natural resources and the protection of the natural environment on their Continental Shelves which can extend to over 200 nautical miles from their coastline. This offers an opportunity to protect archaeological remains through development schemes that regulate activities such as aggregate extraction, the construction of wind farms, laying of pipelines and cables, and prospecting for oil and gas.

Finally, current programmes and policies of the EU in relation to the North Sea are set out in the context of the Lisbon Strategy of 2000, which has the intention of making the EU a more competitive and knowledge-based economy by 2010, through sustainable use of the environment. For the European seas, this aim has been translated in a European Maritime Policy and the Marine Strategy Directive. On the whole, the focus of these policy documents is very much on the natural environment and biota, with a marginal role for the (pre)historic environment. The same can be said for the Natura 2000 directive which aims to create a European ecological

network of protected areas, including a network of 'marine parks'. In the UK, the forthcoming Marine Bill provides for designation of Marine Conservation Zones, which will also be based around natural environment considerations. Nevertheless it will be worthwhile to seek out ways of conserving heritage sites and historic landscapes within these 'green' initiatives. This should be considered especially in areas where valuable natural and historic environments overlap, for example on the Brown Bank and Dogger Bank.

Notes

4 Parfitt *et al.* 2005.

5 This limit roughly corresponds with the start of Olduvai palaeomagnetic subchron at 1.95 Myr and the Pliocene/Pleistocene boundary at 2.6 Myr (base Gelasian; Cairns 2007 INQUA congress) or 1.8 Myr (base Calabrian; London 1948 IGC congress) depending on definition (e.g. Gibbard & Cohen 2008). The International Commission on Stratigraphy has formaly established the boundary at 2.6 Myr (*cf.* Nature 459, 3 June 2009, p. 624).

6 There is much uncertainty about the precise inundation date of landscape features such as the Dogger Bank and the Holland-East Anglia land corridor, largely due to postglacial glacio-isostatic subsidence in the periphery of former ice sheets of Scandinavia and Scotland. There was probably sub-regional variation in inundation rates. (e.g. Jelgersma 1979; Ward, Larcombe & Lillie 2006; Vink *et al.* 2007).

7 Occasional finds of Middle Neolithic polished axe blades at the Brown Bank nevertheless point to the presence of seaways at the time (Glimmerveen 2007; Maarleveld 1984).

8 If other North Sea countries participate, their respective North Sea sections will be added.

9 In the UK, some 20 million tonnes of aggregates is extracted on a yearly basis. On the Dutch side some 25 million m^3 is extracted on a yearly basis, but these quantities will increase in the near future for the purpose of coastal protection works.

10 This practice is specific to the Dutch fishing fleet, but will come to an end within the next 5 years or so.

11 Flemming 2002.

12 (Council of Europe) Valletta, Malta 1992. The Convention has been widely signed by both EU and non EU-members. For a full overview: http://www.conventions.coe.int

13 Such as the Belgium 'Wrakkenwet', accepted by parliament in 2007, not yet into force; and the UK Protection of Wrecks Act, 1973. Following Parliamentary scrutiny and debate it is hoped that the latter will be replaced by the provisions of a new Heritage Protection Act, which will permit designation of a wider range of maritime historic assets, including submerged prehistoric sites.

14 This is Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on 'The assessment of the effects of certain plans and programmes on the environment'. The EU Directive 97/11/EC, related to Environmental Impact Assessment, amends the original Directive 85/337/EEC on 'The assessment of the effects of certain public and private projects on the environment', which came into effect in July 1988. Annex III expands on Article 5 to explain that the aspects of the environment likely to be significantly affected by the proposed project includes "...the architectural and archaeological heritage...".

15 United Nations Convention on the Law of the Sea, Montego Bay, Jamaica 1982.

16 Articles 149 and 303 specify that States are responsible for the protection of archaeological and historical objects at sea. One of the main points of departure of this convention however is the freedom of the seas, which means that States have very limited jurisdiction beyond their territorial waters. The dilemma is how to protect heritage without the legal instruments to do so.

17 In October 2008, the UCH Convention was signed by 20 States. At present, none of the North Sea countries is signatory to the Convention. All Member States of Unesco however are committed to the operational rules of the Convention.

18 E.g. MACHU (Managing Cultural Heritage Underwater): a joint project of the Netherlands, Belgium, the United Kingdom, Germany, Poland, Sweden and Portugal (Oosting & Manders 2007; www.machuproject.eu).

19 Articles 1, 2, 8 and 9 of the European Landscape Convention (ratified by the Netherlands in 2005, and the UK in 2006) are of particular importance in relation to the NSPRMF.

20 This depends on the way national heritage legislation is formulated. In the Netherlands the Monuments Act is applied to the territorial waters in the same way as on land, except for aspects such as finds reporting which, onshore, are authorized by local authorities. In the Netherlands territorial waters the sole competent authority for archaeological heritage is the Minister of Education, Culture and Science.

21 UNCLOS, Article 303.2. Few countries have made use of this as yet. One of the exceptions is the Netherlands. From September 2007 the working sphere of the Dutch Monuments Act was extended to cover the contiguous zone.

Section 2 Resource assessment

2.1 Assessment focus

This resource assessment covers both the palaeolandscapes and prehistoric archaeology of the southern North Sea basin. Brief outlines of the current state of knowledge will be presented, thus permitting the identification of knowledge gaps and the definition of research potential. Various aspects will be addressed: stratigraphic and chronological frameworks, landscape surfaces, palaeontological and palaeobotanical assemblages, and archaeological assemblages.

2.2 Stratigraphic and chronological frameworks

In view of the chronological scope of the NSPRMF (see Section 1), Quaternary stratigraphies and chronological frameworks must be considered in relation to their archaeological significance. Assessment of this significance largely involves asking to what extent the available information permits an understanding of archaeological patterns (the 'archaeological landscape') in terms of formation processes and environmental context. These factors refer to chronological control and resolution on the one hand, and to genesis and provenance of the various deposits on the other.

Chronological control of Pleistocene deposits in the North Sea Basin and surroundings has long built on correlations of sedimentary sequences based on lithological properties, geographical distribution and stratigraphic position (Fig. 5, pp. 17-18). Such correlation has allowed *relative* chronostratigraphic frameworks of regional validity to be established, by integrating lithological observations with derived overarching models of landscape evolution and glacial/interglacial cyclicity.[22] Assigning absolute chronology to these chronostratigraphies, however, has been weak until recently, for techniques for dating terrestrial deposits older than *c.*30 Kyr independently have generally not been available: only Late Glacial and Holocene deposits were dateable by ^{14}C. Absolute age estimates of older deposits and fossils were based on biochronostratigraphic and archaeological correlative frameworks from palynology and palaeontology. Correlation of local evidence with sedimentary evidence for glacial and interglacial stages, and with the global-averaged climate history derived from the ocean floor, from deep lakes and from Antarctic ice-core records has been problematic. In the absence of absolute dating techniques, lithostratigraphic and chronostratigraphic frameworks became static and proved to be unsuitable for applied research. In particular inter-regional and international correlation and integration of the various systems in use proved extremely difficult, if not impossible, for certain time spans.[23] In practice, the chronological positioning of individual archaeological 'sites' and inter-site correlations are subject to much debate, and models of occupation histories and behavioural evolution consequently are weak constructs. New techniques such as Optical Stimulated Luminescence dating (OSL), Amino-Acid Racimization dating (AAR) and Argon-Argon dating (on rare interbedded volcanic materials) in the last decade have provided promising results for dating deposits of the last 0.2/0. 5/2Myr. Yet, in the time frame beyond the calibration curves for radiocarbon-dating (e.g. > *c.*26 Kyr), these techniques are experimental and thus the absolute chronology of Palaeolithic cultural heritage in the North Sea Basin and surroundings remains far from resolved. The use of biochronologies (e.g. small mammals) and palaeomagnetic/polarity reversals remains of importance.

For terrestrial areas of the Netherlands, the lithostratigraphic system established in 1975[24] was replaced in 2003 by a revised system. The hierarchical system now in use departs from strictly lithological identification of units.[25] Provenance (e.g. from the Rhine system, local areas, or the North Sea) and sedimentary environment (e.g. fluvial, marine, aeolian, coastal, terrestrial, glacial) plays a role in grouping hierarchical levels (Formations). Within the formations, subunits are typically defined, either formally (of regional importance) or informally (of site or local importance). Chronostratigraphic criteria ('presumed age') were removed from the lithostratigraphic classification system. Chronological control has to be obtained from independent dating of sediments and/or their fossil contents, including non-reworked mollusc shells, mammalian or vegetative remains. The advantage of separating the lithostratigraphic system from chronostratigraphic models is

that mapping becomes independent from dating and from palaeolandscape reconstructions based on incomplete evidence. In other words, observation is separated from interpretation and users are forced to document explicitly the link between lithostratigraphic information and palaeolandscape reconstructions (see Section 3).

In terms of archaeological significance, the strict lithostratigraphic approach, separated from age attribution (whether based on independent dating or on a conceptual age model) has many advantages. The lithostratigraphic system provides a suitable framework for the explanation of archaeological patterns in terms of formation processes, which is a prerequisite for the interpretation of the archaeological record in terms of human behaviour. Furthermore, the system is highly suitable for geological mapping in modern computer environments, in which generic geo-databases are designed to allow multiple types of usage and which demand separation (and documentation) of observations and interpretations at the various levels of data description. In this way, the lithostratigraphic framework fits the need for the development of indicative maps of archaeological potential,[26] as it permits the drawing of inferences about the possible uses of landscape zones from sedimentary properties and architectural relationships.[27]

Clearly, the untying of lithostratigraphic mapping from the dating problem does not mean that the need for sound chronological frameworks is not of major importance. Current practice in the North Sea Basin is to use one or more out of four options to date sediments:

- Direct absolute dating of sediments and/or non-reworked fossil components (e.g. using OSL, AMS ^{14}C dating).[28]
- Direct (relative) dating of *ex situ* components (AMS ^{14}C dating).[29]
- Indirect absolute dating by applying Mean Sea Level (MSL) reconstructions from surrounding sites (time-depth correlation).
- Indirect relative dating based on observed lithostratigraphic position (vertical, lateral) and interpreted palaeogeographic meaning ('before that ice-age').

Direct dating options

Clearly, direct dating on *in situ* sediments and components is usually preferable. Direct dating of *ex situ* components (e.g. mammalian remains) can, however, provide indirect insight into aspects such as any stratigraphic hiatus and reworking of sediments. The developments in OSL and ^{14}C dating techniques extend the scope of these methods, even though error margins become increasingly large with time. Calibrated ^{14}C dating spans the last 26 Kyr. OSL dating of North Sea Basin deposits spans the last 180 Kyr of fairly high natural radiation (Rhine sediment[30]) and *c.*400 Kyr in quartz bearing deposits of extremely low natural radiation.[31] Potentially, experimental work may push luminescence dating to 0.5-1 Myr[32] and allow calibration of ^{14}C data to 50 Kyr[33] at some time in the future.

Indirect dating options

In the late-glacial and Early Holocene – in archaeological terminology the late Palaeolithic and Mesolithic – indirect absolute ages may be inferred from time-depth data relative to Mean Sea Level (MSL). At site level, this provides an age proxy, but not a definite 'hard' age. Choosing the 'right' MSL curve for the any location in the North Sea is critical. There is not *one single* curve for any extensive area of the North Sea due to considerable differential Glacio-Isostatic Adjustment (GIA) in the Late Glacial and Early Holocene,[34] as a result of distance from the centres of Scandinavian and Scottish ice caps and tectonic complexity of the North Sea Basin itself.[35] Neither is there one undisputed geophysical quantified reconstruction of GIA for the study area that has factored in the differential MSL rise related to loss of the ice loading of Scandinavia and Scotland, using a balanced set of both Dutch-German and British sea-level data at the same time. For some critical regions (north and northwest of Dutch North Sea sector, Dogger Bank area) there are few MSL index points. Furthermore, recent studies on sea level fluctuation make it clear that much inter-regional variability exists due, for example, to differential glacio-isostasy and fault tectonics.[36] Time-depth data have to be considered critically when they are used for the chronological framing of stratigraphic features that cannot be dated directly. MSL index point datasets and the method of intersecting paleolandscape surface with a MSL-curve (age-depth graph) are critical for creating dynamic models of landscape inundation (see Section 3).

Two fundamentally different approaches to transgression modelling are possible, both demanding a rigorously scrutinised dataset of sea-level index points derived for the timeframe or area in question, and generally relying on ^{14}C dated basal peat samples. The first approach is to use mathematical-statistical techniques to interpolate palaeo-sea levels between the locations of observations.[37] This delivers a realistic spatially differentiated pattern, but this can only be attributed indirectly to the various causes of change; and it is only reliable in areas where abundant data are available – which is the case for the shallower parts of the North Sea Basin but less so further offshore. The other technique is to use geophysical theory and numerical modelling to predict crustal movement in, and around, the area of the melting last glacial ice sheets. Such models use the position of the ice limit and global mean sea level rise as inputs, and optimize parameters such as ice-volume, crustal elasticity and upper mantle viscosity to fit sea-level index points as well as possible.[38] A benefit of models derived from the second approach is that they have more predictive power and attribute differential displacement to specific physical causes. A problem is that they only do so for those physical processes that are prescribed in geophysical theory. Furthermore, most models (for various reasons) lack a realistic heterogenic crustal model and hence produce smooth modelling results, whereas empirical studies suggest strong differential movements over very short distances, for example along the tectonically active south-western zone of the North Sea Basin.

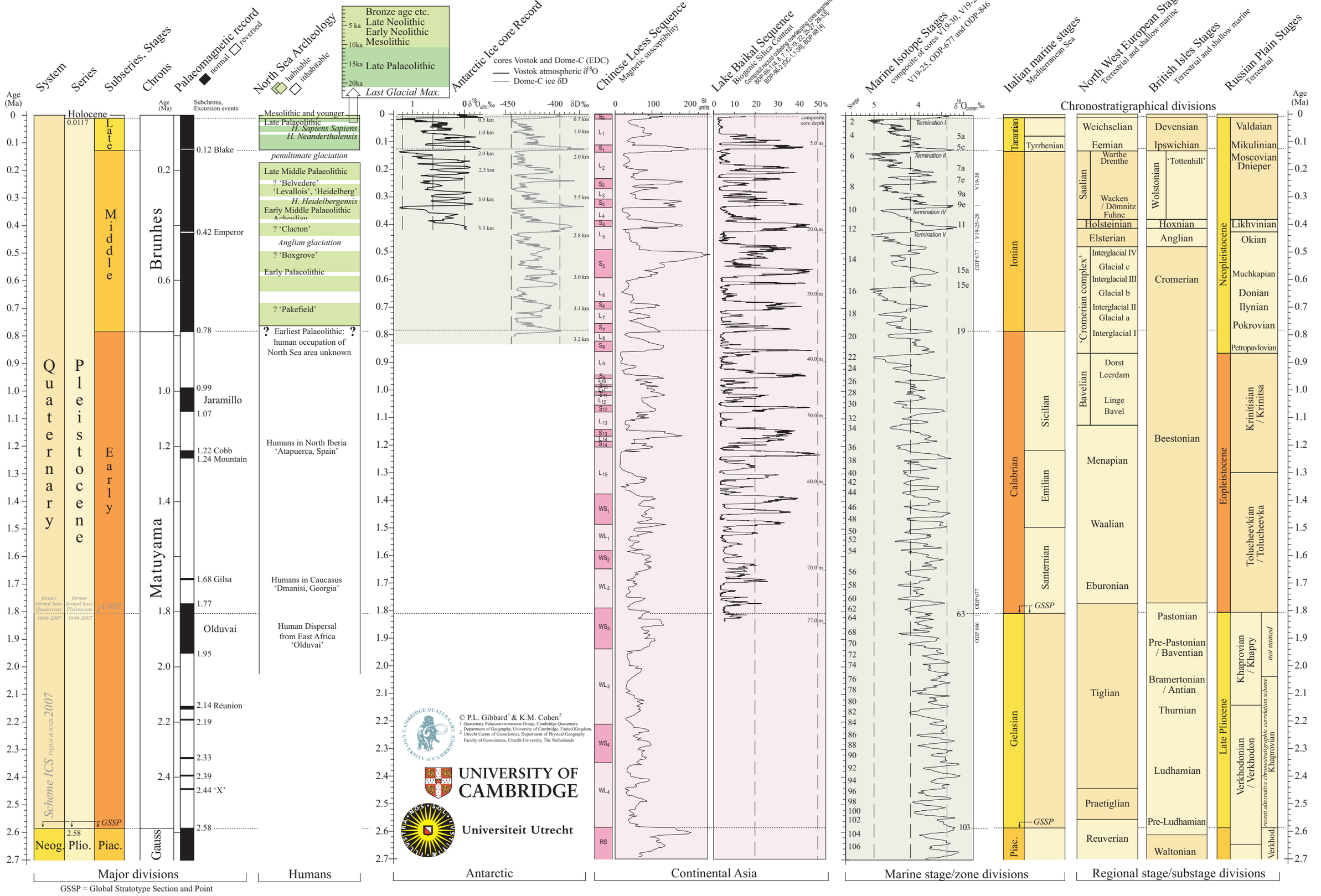
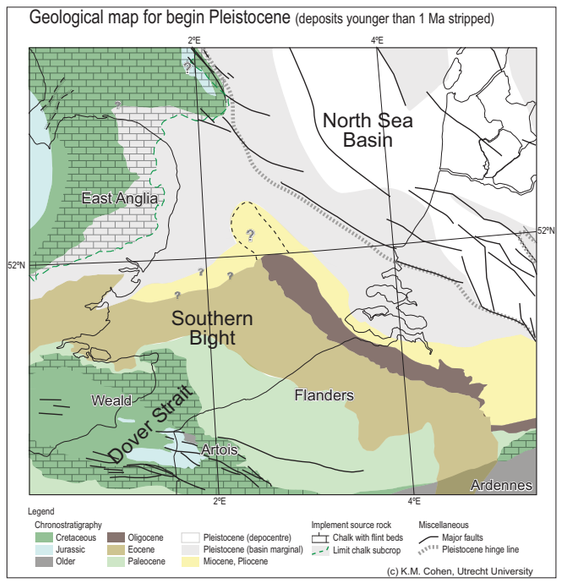
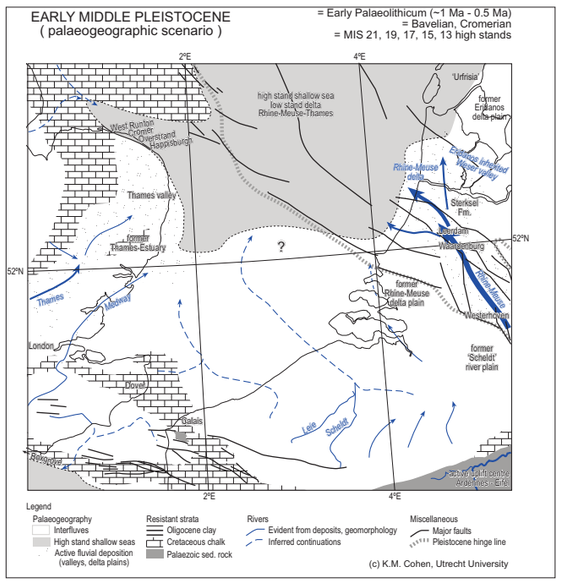
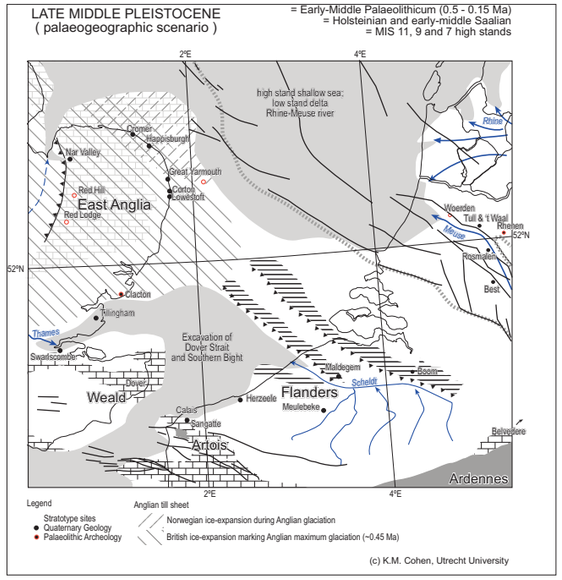


Fig. 5 Chronostratigraphic chart of the Quaternary. (Source: Gibbard & Cohen 2008).







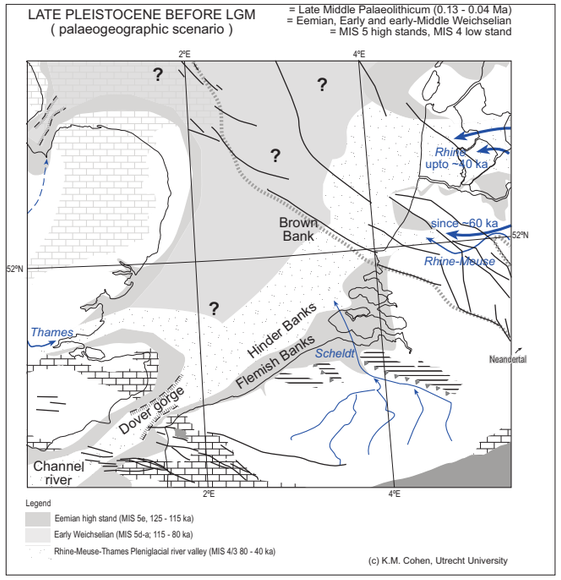
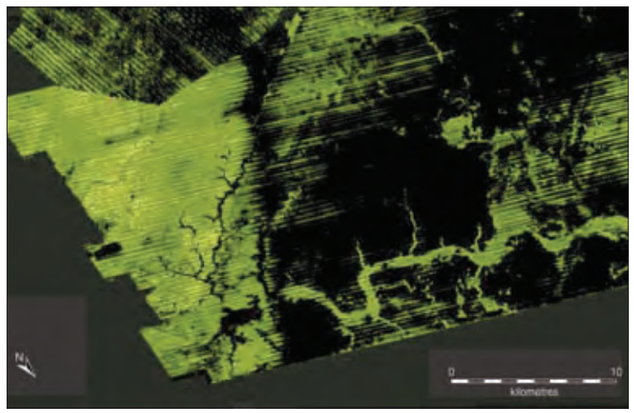


Fig. 6 Palaeogeographic reconstructions of the southern North Sea Basin at the beginning of the Pleistocene, early Middle Pleistocene, late Middle Pleistocene and Late Pleistocene before the last glacial maximum. (Maps by courtesy of Kim Cohen).

2.3 Landscape surfaces

In the early 20th century, finds of prehistoric terrestrial faunal and plant remains and artefacts from the North Sea, combined with the occurrence of extensive intertidal prehistoric land surfaces around the east coast of England and west coast of the Netherlands, led to speculation about the presence and preservation of ancient landscape surfaces below the North Sea floor. These have been largely based on lithological core descriptions from widely spread borehole locations in the North Sea Basin, bathymetric data, and on the archaeological and palaeoenvironmental finds themselves. In addition, data on Holocene sea level rise and Pleistocene sea level fluctuation, as well as information on glacial extension of ice sheets have added to the reconstruction of past environments and



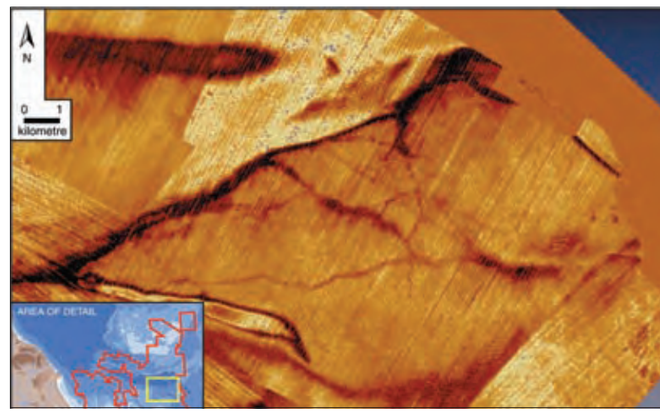


Fig. 7 GIS analysis of 3-D seismic data have permitted the identification of palaeolandscape structures in the Dogger Bank area. Even though the precise age of the various geomorphological structures is as yet to be established, the results demonstrate the huge potential for research. a) The valley of a large river crossing part of the Dogger Bank, later called the Shotton, can be seen snaking across the bottom of the image from left to right. There are small tributaries running into the main river on the left. b) An area of interlocking water channels that has been interpreted as a massive salt marsh. (Images from Gaffney et al. 2009; data courtesy of PGS Ltd.).

to the development of palaeogeographic maps.[39] However, the spatial and temporal resolutions of these maps and models have remained rather coarse, thus restricting their usefulness. Nevertheless, they have under-pinned our thinking about the importance and research potential of the area – a notable example is the concept of 'Doggerland' coined by Bryony Coles – and have thus triggered major research efforts geared at the increase of the scientific understanding of landscape formation processes, besides improving spatial and temporal models of landscape evolution. Two will be considered here.

Several studies have led to models of the development of the Pleistocene drainage system in the area of Dover Strait and Southern Bight, which progressively connected the English Channel and the southern North Sea Basin during Early and Middle Palaeolithic times (700-150 Kyr) (Fig. 6).[40] Renewed interest in the genesis of shelf valley systems in the English Channel and the origin of Dover Strait has followed the availability of high-resolution sonar bathymetric data, as well as lithological and dating evidence collected from continuous cores and exposures in the Netherlands. The data suggest that pro-glacial lakes formed by the end of the most extensive glaciations, (Anglian, Saalian) – before the Dover Strait had eroded to below MSL – covering the southern North Sea area and part of the Netherlands. Erosion in the Dover Strait would largely have been attributable to the spillage of accumulated meltwaters from such lakes, breaching the Weald-Artois anticline to form the later sea strait, and producing the enigmatic scars in the Channel floor.[41] The implications of these insights for an understanding of the Middle/Late Pleistocene archaeological record in NW-Europe are far-reaching. Even though the catastrophic flooding hypothesis had been proposed as early as 1874,[42] its testing had to await technological advances in sonar technology, analysis of vibrocores to determine sediment sources, and of direct OSL dating on sediments. A re-assessment of lithological and lithostratigraphic data, as well as additional sampling and independent dating will, however, be necessary in order to substantiate this hypothesis.

Maps of Late Glacial/Holocene landscape development in the area around the Dogger Bank ('Doggerland') during late Palaeolithic, Mesolithic and potentially earliest Neolithic times have also been developed.[43] Spatial modelling of high resolution 3-D seismic survey data from the Dogger Bank area have, in addition, permitted detailed mapping of palaeolandscape structures beneath the present sea bed (Fig. 7).[44] The structures imaged from these survey data indicate the survival of fossil drainage systems, lacustrine features and salt marshes over relatively extensive areas. The potential for large-scale mapping of fossil landscape structures by such means is enormous, although field validation of interpretations remains a necessity. In addition, there are some other problems that have to be dealt with in order to increase the usefulness of the resulting maps. These problems involve chronological and 3-D spatial synchronisation of features, visibility enhancement, (e.g. for shallow and small-scale features), and filtering of unwanted artefacts of the processing methodology on deeper 'time slices'. The use of seismic data can be effective at multiple spatial scales, depending on the resolution required in relation to the research questions under consideration.

Despite the restrictions and problems mentioned above, the archaeological significance of palaeolandscape mapping is indisputable. When combined with sea level data (see the preceding paragraph), independent dates and sediment-source information, it will become possible to develop dynamic models of landscape evolution that can be linked to archaeological information about prehistoric land use by humans. Also, and in combination with lithostratigraphic data, it provides insight into surface intactness

and thus offers a framework for assessing the significance of many of the 'stray finds' such as those dredged up by fishermen. Furthermore, palaeolandscape maps will be useful for management purposes, including the development of indicative models of archaeological potential (see the preceding paragraph) and threat mapping.[45] Finally, it should be stressed that dynamic palaeolandscape models and visualizations provide an appealing means to inform the wider public.[46]

2.4 Palaeontological and palaeobotanical assemblages

Most of the sub-fossil material from the sea floor consists of bones dredged up by the fishing and aggregates industries (Fig. 8). Palaeobotanical remains are less frequent and mainly consist of tree stumps. For many decades, materials have been collected on an *ad hoc* basis and could not be considered representative of the faunal and botanical assemblages originally present. Nevertheless, in spite of coming from disturbed contexts, these items have contributed to a developing understanding of the palaeoecology of the North Sea, which has also been enhanced by data from *in situ* finds, such as submerged forests, in intertidal zones. However, since the late 1980s, museum staff in the Netherlands have developed close collaboration with Dutch fishermen, and there have been a number of targeted palaeontological 'fishing' expeditions: information has been collected on a systematic basis by a group of palaeontologists led by Dick Mol.[47] Data from these sources have increased insight into species variability, aspects of time-depth and chronology, preservation conditions and location.

Palaeontological assemblages from the southern North Sea have so far mainly been recovered from two principal areas: the Brown Bank and Eurogeul. The composition of the assemblages – comprising terrestrial and marine mammals – is heterogeneous and clearly reflects a range of climate-related environments and chronological stages.
Broadly speaking, the collections are dominated by Late Pleistocene cold 'mammoth-steppe' faunal associations (including woolly mammoth and rhinoceros, bison, horse, reindeer) and warm climate Pleistocene and Holocene faunal associations (dominated by straight-tusk elephant, hippopotamus, aurochs, various species of deer, and wild boar). Most of the remains can be assigned to a limited range of commonly-reported species, such as woolly mammoth and horse; but there have also been occasional reports of extremely rare species, including the sabre-tooth cat and wolverine. In some cases, notably the remains of a hitherto unknown bovid, specific identification has become possible by analysis of preserved DNA. In addition to Late Pleistocene and Holocene species, several Early Pleistocene species have been identified: mastodon, musk ox, southern mammoth, rhinoceros, and beaver. On the basis of finds made so far, Middle Pleistocene terrestrial mammalian remains appear to be relatively rare in the North Sea area.

Fig. 8 A 'catch' from the Eurogeul, 22 May 2009. (Photo: Klaas Post).

Sea mammals are also represented in the palaeontological record. Again, the collections comprise associations typical of cold climate, such as walrus, ringed seal, blue whale, grey whale, white whale, and warmer conditions: grey seal, killer whale, bottle nose dolphin, sperm whale, and porpoise. From the small number of AMS radiocarbon dates there appears to be a time gap within the Holocene assemblages between about 5000 and 3000 BP. Whether this is a result of biases in the palaeontological record itself, research bias, or indeed a reflection of palaeoenvironmental events is, as yet not clear. As is the case for the terrestrial mammal record, Early Pleistocene and earlier marine species are represented in the collections. Middle Pleistocene marine mammal remains have not been identified as yet.

As these faunal remains are mainly trawled up from the sea floor and lack a stratigraphic context, chronological control depends on relative degrees of fossilisation, biochronological correlation and AMS dating. However, the relative degree of fossilisation has proved to be of restricted value: in some cases the age inferred was not supported by AMS radiocarbon determinations, which were younger than expected). The same holds true for age estimation on the basis of biochronological reference frameworks: AMS dates on bones of several species that were previously believed to have been extinct for several 100 Kyr now suggest survival far into the Weichselian/Devensian. This makes it difficult to assess the significance or validity of suggested chronological hiatuses in the palaeontological record, such as the absence or rarity of terrestrial and marine Middle Pleistocene species.
Although AMS dating has shed some new light on the age of mammal remains, the method does not permit dating beyond the 50 Kyr limit; and calibration beyond the 26 Kyr limit is as yet not recommended. U/Th-dating on bone samples could potentially extend this limit further, but this technique requires the availability of sediment samples for assessment and validation of results. AMS radiocarbon dating is, however, a valuable tool for materials post-

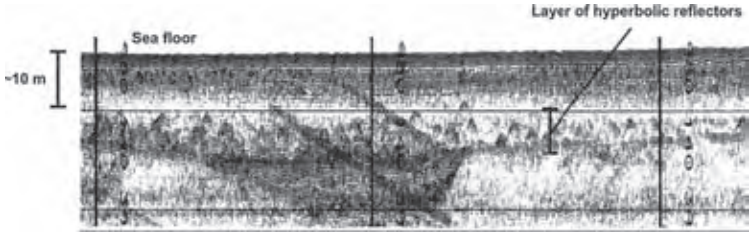


Fig. 9 Seismic survey of an infilled river valley on the eastern end of Dogger Bank (water depth 45-50m), showing the infered presence of a drowned forest (hyperbolic reflectors). (Source: Hansen 1981, 18-9).

dating the Last Glacial Maximum (LGM). Consistent dating results have been obtained for Early Holocene animal and human bone remains originating from the Brown Bank and Eurogeul area.[48]

The presence of ancient DNA in bone from the North Sea floor indicates that preservation is good, and that there is potential for high resolution research. In addition, the large amount of bone material obtained from the North Sea could be analysed statistically in terms of e.g. species composition and subregional variability, age composition and date. These statistics help to provide insight into the representativity of the sample in relation to taphonomy, and evaluate whether more sophisticated, quantitative analysis is justified.

Even though there is little contextual information from stratified finds at present, linking information on the distribution of the various species and assemblages with lithostratigraphic and palaeogeographic information will, without doubt, enhance understanding of taphonomic processes. In turn, this will inform the assessment of significance, and subsequent interpretation of palaeontological assemblages, in relation to broader questions of landscape evolution and landscape use by prehistoric humans.

Palaeobotanical information also contributes to the understanding of former landscapes and their uses. Information comes from palynological analysis of sediment samples and identifications of plant macrofossils, such as pine cones and tree stumps. The latter can occur in vast quantities over large areas, representing submerged Holocene forests; but so far investigations have been focused on the *intertidal* submerged forests of the British Isles and the Netherlands.[49] Some early discoveries of such submerged forests did not, unfortunately, result in detailed recording, and many exposures are no longer accessible. Nevertheless, there is still considerable potential for detailed investigation, though this potential is directly threatened as a result of coastal erosion and coastal risk management schemes.[50] Further offshore, submerged forests are indicated directly by tree stumps dredged from the sea floor, and indirectly by seismic profiles: hyperbolic reflectors related to particular layers may point to the presence of tree stumps (Fig. 9).

Palaeobotanical remains not only provide a rich source of information for landscape reconstructions, but can also reveal information

Fig. 10 One of the hand axes from area HAML240 off Great Yarmouth. The discovery has resulted in a joint research project involving archaeologists and geologists from British and Dutch institutions. (Photo: Stichting Cultureel Erfgoed Zeeland).

about anthropogenic impacts on vegetation and landscape, particularly from pollen diagrams.[51] There is much debate on the issue of Mesolithic, and even Upper Palaeolithic, hunter-gatherer modification of the landscape,[52] and also about the role of grazing pressure from large herbivores.[53] By combining botanical and faunal data from the North Sea it should be possible to develop models of the relationships between the dynamics of vegetation, fauna and human behaviour; but of course reliable dating is a prerequisite.

2.5 Archaeological assemblages

As is the case with faunal and botanical remains, artefacts from the North Sea have mainly been dredged during fishing and aggregate extraction, and generally lack contextual information. Archaeological finds along the North Sea coasts attracted the attention of antiquarians during early 20th century: a bone barbed point collected in 1932 from a lump of peat dredged from the Leman and Ower Banks proved that there had been prehistoric occupation of the North Sea. Collection of material on a larger scale during the early 1970's further emphasised the archaeological potential of the North Sea.[54] These finds, especially those from the Brown Bank and the Eurogeul, included worked antler, and antler and bone tools, were believed to be largely Mesolithic in date: they included an impressive collection of around five hundred Early Mesolithic barbed bone and antler points from the Eurogeul-Maasvlakte area of the Netherlands.[55] Subsequent targeted fishing expeditions and collaboration with fishermen resulted in further finds of Middle Palaeolithic, Mesolithic and Neolithic age.[56] Together with Middle Palaeolithic artefacts recently dredged from off the East Anglian coast (Fig. 10), these discoveries indicate the chronological span of material and its potential for archaeological research.[57]

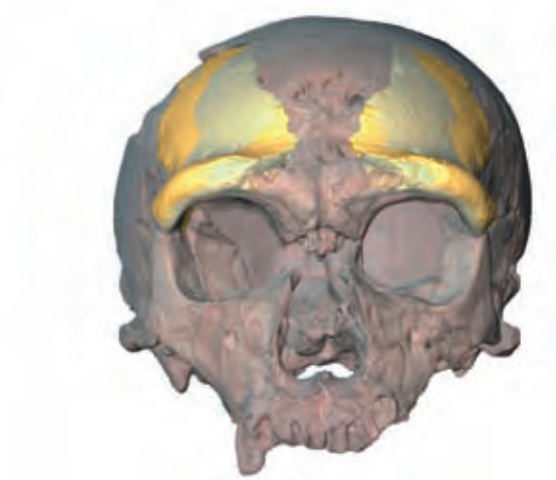


Fig. 11 A high resolution CT scan of the Zeeland Ridges skull fragment (right frontal part in yellow tones; left side mirrored) mounted onto the La Chapelle aux Saints (France) Neandertal skull which is about 60 Kyr old (Image: Max Planck Institute for Evolutionary Anthropology, Leipzig).

In summary, the archaeological assemblages consist of stone, bone and antler artefacts, as well as some human bone, and animal bones with cut marks. The great majority of these materials originate from an aggregate dredging area at Great Yarmouth,[58] Brown Bank, Leman and Ower Banks, Eurogeul-Maasvlakte and the coastal zone in front of Zeeland.[59]

Most of the stone artefacts are Middle Palaeolithic flint tools, principally hand axes and side-scrapers, flakes and cores. Cut marks reported on some Late Pleistocene animal bones, with AMS radiocarbon dates >50 Kyr, from the Eurogeul area, suggest butchery. Significantly, a fragment of a Neandertal frontal bone (Fig. 11) has been identified among Pleistocene bone material from the Zeeland coast, originating from a zone where several handaxes were collected.[60] Upper Palaeolithic artefacts are not, as yet, known from the North Sea itself. A number of 'reindeer' bones and antler fragments (associated with a 'Lyngby adze') have been assigned to the Ahrensburgian and it has been claimed that they show butchery marks.[61] However, the attribution of the bones and antlers to reindeer is not certain, and the anthropogenic nature of the 'cut marks' is questionable. None of the many reindeer remains collected from elsewhere in the North Sea show signs of human modification, and most AMS results point to dates well before the late glacial Ahrensburgian.[62] Nevertheless, in view of the presence of Upper Palaeolithic sites on or near the modern coasts of the Netherlands and British Isles, there well may be submerged Upper Palaeolithic 'sites' and landscape surfaces.

In contrast to the apparent Upper Palaeolithic 'hiatus', Early Holocene, Mesolithic materials are well represented and have been reported mainly from the Brown Bank and Eurogeul areas (Fig. 12). The finds are predominantly bone and antler artefacts, including tools such as shaft-hole picks, socketed axes and barbed

Fig. 12 A 'mace head' (Geröllkeule), an antler adze and a human mandible dated to the Mesolithic. (Photo: Jan Glimmerveen).

points, and there is also some production waste, including bones and antlers with grooves. Mesolithic stone artefacts are uncommon, although two *Geröllkeule* or maceheads are conspicuous exceptions. In addition to the artefacts, the collections also include Mesolithic human bones. Two complete Middle Neolithic flint axe blades, (probably made of Limburgian or Belgian flint), and both collected from the Brown Bank, are also noteworthy (Fig. 13).[63]

Due to the lack of contextual stratigraphic information, the dating of the archaeological materials is based on typological and technological characteristics and/or on direct AMS determinations. Direct dating clearly applies only to organic items. The chronological positioning of the Middle Palaeolithic lithic assemblages is particularly problematic in absence of lithostratigraphic correlation. Notwithstanding some exceptions (such as *bout coupé* hand

axes and Szeletian leaf points), the chronological resolution of artefact features is poor, with uncertainty margins over 100 Kyr. Dating assemblages is, however, essential for modelling repeated colonisations related to glacial/interglacial cycles and the topographical reshaping of the North Sea Basin. Linking spatial information to palaeolandscape and lithostratigraphic data will be a fundamental part of future research.

This is also the case for the typological and technological dating of Mesolithic and Neolithic artefacts, but artefacts of these periods can be dated much more precisely than those of the Middle Palaeolithic: the Neolithic axe blades, for example, date from around 5300 and 4000 BP (uncalibrated). Most post-glacial artefacts from the North Sea, however, are of bone and antler, and so can be dated by AMS. Results obtained so far demonstrate clustering of dates between *c.*10,000 and 8000 BP (uncalibrated), corresponding to the Pre-boreal and Boreal, and in advance of inundation. Several dates from human bones also fall within this range.[64] This does, however, not mean that *all* bones of humans and 'boreal' mammal species (e.g. red deer and wild boar) can be assumed to be of Mesolithic age. In one case, an AMS date on a human bone indicated it to be *c.*200 years old. The need for independent dating is also demonstrated by the AMS results on a sample from a worked piece of *Prunus* (possibly blackthorn) wood, dredged up from the part of the Brown Bank where Mesolithic material is frequent, which turned out to be modern. Losses of people and materials from vessels, combined with longer-distance transport from shores, contribute to the sea-floor assemblage.

Fig. 13 One of the Neolithic axe blades (length about 32 cm) from Brown Bank. The axe blade shows typical 'marine patination'. (Photo: Jan Glimmerveen).

The composition of the archaeological collections indicates that they are extremely biased, for two principal reasons. First, there is a bias of size: small objects are very unlikely to be collected. Artefacts dredged up during aggregate extraction are retrieved by collectors at onshore wharfs from the reject piles, which consist of the large gravel/boulder fraction. The finer gravel fraction, which may contain smaller tools and production waste, is inaccessible, since it is directed into large silos. Material dredged up in fishing nets may contain smaller items, but that plainly depends on mesh width and the gradual filling of nets as they traverse the sea floor. A second source of bias relates to artefact recognition: the expertise of collectors. Materials brought up in fishing nets are selected onboard by fishermen, and only rarely by professional archaeologists, so only the more conspicuous and obvious artefacts are generally retained. Artefacts smaller than a few centimeters in dimension are thus under-represented in both the Middle Palaeolithic and Mesolithic/Neolithic collections. Finally, bias may occur due to differential preservation of materials. However, in view of the generally good preservation of unmodified faunal remains and of Holocene bone and antler tools, which sometimes retain preserved fragments of wooden shafts, the potential for collection of prehistoric artefacts appears to be very high.

Notes

22 E.g. Laban 1995; Laban, Cameron & Schüttenheim 1984.

23 Van Gijssel 2006.

24 Zagwijn & Van Staalduinen 1975.

25 Weerts *et al.* 2000.

26 In the Netherlands, the national Indicative Map of Archaeological Values (IMAV; Dutch: Indicatieve Kaart van Archeologische Waarden, IKAW) expresses the relative chance (low, medium, high) of archaeological sites being present in areas, based on statistical relationships between soil/hydrological properties and the frequency of archaeological observations (Deeben, Hallewas & Maarleveld 2002; Deeben 2008). It should be noted that for the province of Flevoland – a reclaimed part of the former Zuiderzee – the IKAW expresses the relative possibility of areas containing archaeological manifestations of certain types of behaviour, based on palaeolandscape models and knowledge on hunter-gatherer/early farmer behaviour (Peeters 2007, 2008). An Indicative Model of Archaeological Potential (IMAP) – or even an Indicative Model of Research Potential (IMRP) when the focus is not exclusively on archaeological phenomena – would express the expected possibility (not probability) of an area containing in situ archaeological remains (Ward & Larcombe 2008) or having significance in relation to specific research questions (e.g. Peeters 2007).

27 E.g. 'where on the North Sea floor did pre-Anglian Rhine valleys rework flint-bearing Thames gravels that could be exploited by early hominids?'.

28 AMS = Accelerator Mass Spectrometry.

29 This approach provides only results at an indicative level and there are uncertainties about reliability of results.

30 Busschers *et al.* 2007.

31 Schokker *et al.* 2005.

32 E.g. Wallinga *et al.* 2005; Kars, Wallinga & Cohen 2008.

33 E.g. Van der Plicht *et al.* 2004.

34 E.g. Kiden Denys & Johnston 2002; Vink *et al.* (2007) contra Behre (2007).

35 E.g. Houtgast, Van Balen & Kasse 2005; Cohen, 2005.

36 Kiden, Denys & Johnston 2002; Vink *et al.* 2007.

37 E.g. Cohen (2005) for the Rhine-Meuse delta; Smith *et al.* (2006, 2007) for British record.

38 E.g. Shennan *et al.* 2006; Lambeck *et al.* 1996; Peltier 2004; Steffen 2006.

39 E.g. Coles 1998; Zagwijn 19XX; De Mulder *et al.* 2005;

40 Busschers *et al.* 2007, 2008; Menot *et al.* 2006; Gibbard 2007; Gupta *et al.* 2007.

41 Busschers *et al.* 2007, 2008; Menot *et al.* 2006; Gibbard 2007; Gupta *et al.* 2007.

42 Reid 1913; Roep *et al.* 1975; Smith 1985; Gibbard 1995.

43 Fitch, Thompson & Gaffney 2005; Gaffney, Fitch & Thompson 2007.

44 Fitch, Thompson & Gaffney 2005; Gaffney, Fitch & Thompson 2007. Some initial results on feature recognition from seismic data in shallow waters in the Dutch coastal zone are also encouraging (Rieu *et al.* 2005).

45 Fitch, Gaffney & Thompson 2007, p.116-7.

46 This work has resulted in extensive media coverage.

47 E.g. Glimmerveen *et al.* 2004; Glimmerveen, Mol & Van der Plicht 2006; Mol *et al.* 2006.

48 Glimmerveen *et al.* 2004; Glimmerveen, Mol & Van der Plicht 2006; Mol *et al.* 2006.

49 See e.g. Bell (2007) for an overview for western Britain, and Hazell (2008) for England as a whole. It should be noted that submerged forests are also found in the Baltic area and along other North Sea coasts (Fisher 2004).

50 For example, a submerged forest at Erith in the Thames Estuary is dated to 2580-2200 cal BC to 990-790 cal BC with trees of differing dates exposed at various levels on the shore (Seel 2000).

51 Bell & Walker 2005.

52 E.g. Bos & Janssen 1996; Bos & Urz 2003; Bos *et al.* 2005; Dark 1998; Simmons 1993.

53 Vera 1997.

54 Louwe Kooijmans 1970/71.

55 Verhart 1988.

56 Glimmerveen *et al.* 2004; Glimmerveen 2007.

57 In the UK, English Heritage has developed a finds reporting protocol with the British Marine Aggregate Producers' Association, and implemented by Wessex Archaeology with funding from the ALSF.

58 The Great Yarmouth finds were dredged up from UK waters, but were collected by Mr. J. Meulmeester at a aggregates wharf at Vlissingen in the Netherlands.

59 Glimmerveen *et al.* 2004, 2006; Mol *et al.* 2006; Verhart 2004; Wiltenburg 1980.

60 Hublin *et al.* in press.

61 Van Noort & Wouters 1987.

62 Glimmerveen *et al.* 2004, 2006.

63 These finds also raise the question of prehistoric seafaring (Lanting 1998; Van de Noort 2004, 2006).

64 Glimmerveen *et al.* 2004; Glimmerveen pers. comm.

Section 3 Research agenda and strategies

This section provides an outline of a Research Agenda, based on current research, which indicates the potential of the region, and on the evident gaps in knowledge identified in the previous section. It will be structured around a series of overarching themes and more specific research topics. These themes and topics address the various aspects of the human use of former landscapes in the southern North Sea Basin from spatially and temporally variable perspectives. The definition of themes and topics is followed by a Research Strategy which identifies priorities, and outlines potential short and long-term projects.

Theme A: Stratigraphic and chronological frameworks

The geological evolution of the southern North Sea Basin is complex and involves successive phases of marine, lacustrine, fluviatile and glacial sedimentation and erosion, as well as the consequences of tectonic processes. This complex, and geographically variable, sequence of events had effects not only on landscape evolution and the potential for landscape use by early prehistoric people, but also taphonomically on the differential preservation of deposits containing archaeological material. To interpret the archaeological and palaeolandscape information, further development of stratigraphic and chronological frameworks is therefore critical.

Topic A.1: Lithostratigraphic classification and chronological anchoring. The seabed of the North Sea must not be read as a simple, single-phase landscape, but as a complex stack of deposits, with buried palaeosurfaces, all extensively dissected by later erosional processes, and sometimes buried by Holocene marine sediments. It has to be addressed at local, as well as regional, scales. Our understanding of the deposition and sedimentary architecture of the basin fill must underpin our perception of North Sea landscape evolution and the relative importance of events and processes represented; and rigorous lithostratigraphic classification and chronological anchoring of units and complexes is of prime importance in achieving this understanding. Chronostratigraphies currently in use in the UK and Netherlands remain difficult to correlate, so there is a need for primary geogenetic classification of lithological units and complexes. This must be combined with independent dating of sediments and other *in situ* components. This will enable a better understanding of stratigraphies, besides providing the basis for correlation in spatial and temporal terms.

Topic A.2: Sea level change and glacio-isostasy. To understand, and to develop predictive models for patterns for, the Latest Palaeolithic and Mesolithic occupation in the North Sea area, it is important to establish a benchmark model for the Late Glacial/Early Holocene transgression of this area. Ideally, such a model should provide a relative sea-level position for any location within the study area over the relevant time period, the last 20 Kyr. Plainly, this should include an estimate of uncertainty. Such a dataset could then be intersected with mapped palaeosurfaces to yield indicative age estimates for marine submergence and to predict palaeo-coastline positions; for example this might help to define estuarine and deltaic sites where sites may be preferentially preserved. Such a research effort related to archaeological prospection would have considerable overlap with studies of Holocene sea-level rise and glacio-isostatic adjustment (GIA). These aim to enhance understanding of relative sea-level rise and the present-day depth of palaeosurfaces, in relation to past local subsidence and absolute, global, sea level rise. Understanding patterns of differential subsidence and uplift in the North Sea area is important to enable us to extrapolate back palaeo-landsurfaces and sea-surfaces from the depths at which they are recorded today to their elevations in relation to sea level when they were formed.

Topic A.3: Survival of deposits of archaeological significance. Due to the dynamic nature of past and current environments in the North Sea basin, deposits of archaeological significance have not survived to the same extent everywhere. Preservation potential is unevenly spread and research and management strategies that do not adapt to this will generate a biased picture of the overall North Sea floor cultural heritage. Understanding the nature, timing and spatial extent of erosional processes and the fate of reworked deposits is crucial to the assessment of remnant sedimentary sequences and the archaeological landscape.

Topic A.4: Biostratigraphies and absolute dating. Biological markers, especially the presence of particular plant and animal species, have long been used for relative dating. However, the reliability of such markers is problematic, because of the paucity of independent

absolute dates. Since there are abundant faunal remains from the southern North Sea, extensive dating of these remains can contribute to the construction of sound chronologies. These can also help with the chronological anchoring of lithological units and complexes (see Topic A.1), as well as to the assessment of stratigraphic intactness (see Topic A.3). However, an important aspect that has to be taken in consideration, and which requires special attention, concerns the possibility of underwater ^{14}C neogenetic enrichment in porous materials such as shell and bone.[65] This can result in younger dates or even 'positive' results for materials that, in fact, are too old for radiocarbon dating.

Theme B: Palaeogeography and environment

As has been noted in Theme A, the North Sea basin has undergone a complex process of palaeogeographic change, associated with a remarkably wide range of environments. Early hominins and later hunter-gatherers were an integral part of these dynamic landscapes, at varying spatial and temporal scales. Unlike us, they were just one amongst many components of the ecology, and their impacts were sustainable. With the development of high resolution geophysical techniques, combined with data from palaeoecology and sedimentology, the development of spatio-temporal models of past land surfaces and environments comes within reach. This is instrumental to the increase of information value of data points and understanding of the relationships between humans and the landscape.

Topic B.1: Middle/Late Pleistocene reshaping of topography and river drainage systems. Glaciers and river drainage systems have played a fundamental role in the evolution of landscapes throughout the Pleistocene. The Elsterian/Anglian, Saalian/Wolstonian and Weichselian/Devensian glacial stages in particular have had major impact in reshaping the topography. Recent studies of depositional and erosional environments along the Saalian ice margin suggest a fundamental reshaping of the southern North Sea Basin, which involved the diversion of interglacial drainage systems, and made possible the first major transgression through the newly-opened Dover Strait during the Eemian/Ipswichian. During the last glacial (Weichselian/Devensian) Rhine-Meuse-Thames drainage was diverted toward the 'Channel River', with a watershed between the northwest Netherlands and East Anglia.[66] In earlier glacials there was a much smaller 'Channel River' system receiving flow from the Seine, Somme and perhaps the Thames and Scheldt. Concurrently Rhine-Meuse drainage flowed northwards, except during the extreme maxima of Saalian/Wolstonian and Elsterian/Anglian glaciations when pro-glacial lakes are thought to have formed in this area: see Section 2). Recognizing changes in drainage direction, and establishing the timing of these palaeogeographic changes, must underpin understanding of subsequent landscape development and the suitability of the area for human habitation.

Topic B.2: Development of the Weichselian/Devensian landscape. Climatic fluctuations during the last Ice Age are better understood than those of previous glacial stages, due to the better survival of deposits and the more precise chronology provided by radiocarbon dating. Within this glaciation Neanderthals disappeared from the European landscape and were replaced by anatomically modern humans. However, even though the Weichselian/Devensian is comparatively well understood, there are still considerable uncertainties about environmental processes, for dating is still not so precise as might be desired, and the proxies employed are in some cases of doubtful reliability. A thorough understanding of the speed and nature of climate and environmental change is needed to elucidate hominin responses to changing conditions. Certainly, the last glacial stage must not be seen as a single cold spike that separates 'before' from 'after'.

Topic B.3: Palaeogeographic evolution after the Last Glacial Maximum (LGM). As a result of post-LGM melting of ice sheets, the geography of the North Sea basin changed: from a fully terrestrial, periglacial environment to a full marine environment. Understanding the speed and mode of this major transition is essential if we are to understand hunter-gatherer uses of these highly dynamic landscapes that were possibly affected by a tsunami that followed the Storegga mudslide.[67] Recent analysis of geophysical data has shown that large areas of post-LGM landscape surfaces are likely to be well preserved in various parts of the region.[68] Further detailed analysis of data will increase understanding of the extent of survival of these surfaces, besides their interpretation in terms of physical geographic features. Spatial analysis and absolute dating will be required to reconstruct the process of change from a diverse terrestrial landscape through its submergence and subsequent modification by marine processes. Understanding the positions of coastlines, the timing of transgression, the rate of inundation both horizontally and vertically, and quantifying GIA (Topic A.2) will all be necessary for landscape reconstruction. These should help interpretation of the surviving residual blocks of post-LGM palaeosurfaces. A separate research topic would relate to the potential survival of North Sea islands into the Neolithic.

Topic B.4: Quaternary palaeoecology. The North Sea Basin is extremely rich in faunal remains and plant macro- and micro-fossils, especially those contained in sediment blocks recovered via fishing and aggregate extraction activities, or from vibrocores. Our understanding of past environments in terms of variability in animal and plant communities through time and spatially has, until recently, come largely from terrestrial sites. Data from the North Sea Basin provide an opportunity to supplement significantly the dry-land record. The exceptional preservation of DNA in bone provides new opportunities for studying species variability. The collection of further material, particularly where related to a stratigraphic context, combined with AMS dating of bone samples, will enhance the scientific value of material collected previously. New data and their interpretation will improve our understanding of the early human environment.

Theme C: Global perspectives on inter-continental hominin dispersals

During the course of human evolution several species of hominids have spread across the planet. Oceans and seas have generally been considered to be major obstacles to colonisation of new land, yet early humans managed to populate the most remote areas. Coastlines may have played an important role in this process.[69] Plainly, coastlines were dynamic: they responded, ultimately, to climate change. For this reason, understanding changing coastal morphology will be essential if we are to gain insight into the process of early human dispersal. The southern North Sea is an exemplary case study.

Topic C.1: North Sea coastal dynamics and human uses of coastal zones. From a terrestrial viewpoint, coastlines are often seen as marginal, lying along the edge of land masses. However, coasts are by their very nature ecotones, and so offer a very wide range of resources potentially exploitable by hominids: they are exceptionally productive and diverse. The study of the human uses of dynamic coastal zones can shed further light on the significance of coastlines in terms of early human dispersal.

Topic C.2: Pleistocene North Sea level oscillations and population of islands. The present North Sea area has seen an alternation of marine and terrestrial conditions due to Pleistocene climate change. Due to long-term sea level fluctuations bodies of high land have become islands or, at other times, were hills. This change in geographic context, over vast spans of time, must have had profound effects on local populations and wider population movements.

Theme D: Pleistocene hominin colonisations of northern Europe

The earliest well dated evidence for the presence of early humans in northern Europe has come from a site at Pakefield, on the coast of Suffolk in England: *c.*700/600 Kyr.[70] The very rich Palaeolithic record from Britain and the northern European Continent suggests, at least, semi-continuous, occupation during much of the Middle Pleistocene prior to the Eemian/Ipswichian. Despite favourable climatic conditions during the Eemian/Ipswichian, the British Isles and parts other parts of northern Europe show no evidence for human presence at that time. It is not until the Weichselian/Devensian that there is evidence for renewed human occupation, as evinced by a rich archaeological record. Britain seems to have been re-colonised around 60 Kyr ago. The reasons for these patterns of alternating occupation and apparent abandonment are, as yet, poorly understood, but it is probable that major reshaping of the North Sea Basin and drainage systems in North West Europe played an important role.

Topic D.1: Early human exploitation strategies in changing environments. Early hominids have been present in northern Europe for around 700 Kyr or longer. Climate oscillations resulted in geographical change and the distribution and composition of biomass. The archaeological record seems to indicate that during the Early and Middle Palaeolithic there were various strategies for exploitation of this biomass. There is need for increased understanding of the ecological niches of early hominids, and their subsistence strategies, under variable climatic and environmental conditions. This must be related to the distributions of both hominin and non-hominin populations.

Topic D.2: Natural barriers for early hominin expansion. The Late Saalian/Wolstonian seems to mark an abrupt break in the Pleistocene occupation of Britain. As noted above, there was profound re-shaping of the southern North Sea basin and its drainage patterns (see Topic B.1) during the Saalian-Eemian/Ipswichian. We need to understand change at the Saalian/Eemian transition by comparison with earlier and younger periods of climatic amelioration of similar magnitude: the Holsteinian/Hoxnian, intra-Saalian, intra-Weichselian, and Weichselian/Holocene. Similarly, enlarging our perception of occupation sequences is crucial in terms of developing further ideas on the role of natural barriers in early hominin dispersal.

Theme E: Reoccupation of northern Europe after the Last Glacial Maximum (LGM)

The archaeological evidence indicates that northern Europe was deserted during the LGM. Late Weichselian (Devensian) climate fluctuations resulted in transient amelioration of environmental conditions, and triggered re-occupation of parts of northern Europe, as far as southern Sweden.[71] The archaeological evidence for human northwards colonisation during the Late Glacial has come from numerous sites, which have been assigned to various cultural assemblages, including the Magdalenian/Hamburgian/Creswellian, Federmesser and the Ahrensburgian/Long Blade. At present, the understanding of the process of re-occupation, in terms of subsistence strategies and spread over time, is poorly understood. This is partly due to the limits of absolute dating methods, besides a historically-conditioned focus at typological and/or functional aspects of tool assemblages. It would be more profitable to focus on technological dynamics in a broader sense (*chaînes opératoires*) in a variable ideological-social-economic context.[72]

Topic E.1: Post-LGM occupation flux. The Late Glacial is often considered as a phase of climate amelioration in advance of the Holocene when Mesolithic hunter-gatherers were able to spread over northern Europe. However, over this period there were relatively strong, and sudden, climatic fluctuations, and there is considerable uncertainty about the sequence and timing of stadials and interstadials. In the North Sea Basin there must have been significant environmental changes, offering a range of opportunities for various groups of hunter-gatherers who had differing subsistence strategies. They were all well-adapted to a particular range of environ-

mental conditions and so would have expanded, or retired, as things changed to their advantage or otherwise. Late Glacial archaeological remains must be understood within the context of this rapidly changing palaeoenvironmental setting.

Topic E.2: Occupation strategies. Topic E.1 is largely focused at the presence or absence of hunter-gatherers in space and time, but Topic E.2 addresses the question of recolonisation strategies in terms of mobility and settlement strategies. Post-LGM hunter-gatherers would have been confronted with a range of environments and would have developed particular strategies to make use of these environments. Interpreting archaeological assemblages in terms of specific types of activity – prospection parties, structural resource extraction, or full-range residence – will help us to understand landscape use in a broader sense, and increase our understanding of the dynamics of colonisations of new land.

Theme F: Post-glacial land use dynamics in the context of a changing landscape

Ever since the LGM, the northern European landscape has undergone significant environmental change, both in terms of palaeoecology and palaeogeography. Hunter-gatherers responded to this in an economic sense. However, human landscape use is not confined exclusively to subsistence. Other dimensions involve behaviour linked to domestic – settlement and 'home' bound – activities, transient behaviour such as movement of people between locales, and interactive behaviour, related to social relationships, symbolic communication and ritual.[73]

Topic F.1: Changing landscape structure. Rapid changes due to post-LGM melting of the ice sheet triggered major environmental changes (see Topic B.2). These changes must have had radical effects on hunter-gatherer perceptions of the landscape. In order to increase insight into relationships between man and the natural environment, it is necessary to develop dynamic models of landscape structure, embodying geographical and biotic factors.

Topic F.2: Behavioural diversity among hunter-gatherers. Our knowledge of past hunter-gatherers is based on the terrestrial perspective generally taken by most prehistorians. Rather than seeking to understand the seabed on the basis of what we know from studies undertaken on what is now land, research should focus on a reinterpretation of cultural development as a whole. It is absolutely necessary to ignore and forget modern geography, so as to see an area – sea or otherwise – as a white space, populated only with co-ordinates and 'find spots'; and then to think newly, in relation to what we know about past processes – natural and anthropogenic – about the distribution of the archaeological information displayed upon it. Looking at behavioural diversity in the broadest sense and incorporating the now-submerged lowlands into our understanding of prehistory is likely to have a profound effect on how the terrestrial-based record can be reconsidered and enlarged. Also, concordance of terrestrial and offshore records is needed so as to deepen understanding of the perimarine zone in terms of subsistence and other aspects of human behaviour.[74]

Topic F.3: Maritime archaeologies of the North Sea: As part of global post glacial climate change, the North Sea Basin was transformed from low-lying land area to a full marine environment. At the Pleistocene/Holocene boundary, sea level rose at a rate that is unimaginable today and may have had dramatic effects on perceptions of relationships between people and the land. However, the *meaning* of the sea would not have been constant and may have been viewed differently in terms of the full range of human perceptions and behaviours (see Topic F.2). There is evidence for travel by water in the North Sea basin from as early as the tenth millennium BC, and boats have plainly played an essential role in conveying people, knowledge and material culture throughout the prehistoric period. The ability to cope successfully with the sea, and its estuaries and rivers was dependent on the boat-building and navigational skills of past hunter-gatherers and early agriculturalists alike. The ways in which hunter-gatherers explored the expanding water body of the North Sea and its margins must have shaped people's perception of the landscape and seascape.[75]

Theme G: Representation of prehistoric hunter-gatherer communities and lifeways

The ways in which resources are exploited, neglected or rejected have never been driven entirely by subsistence and economic considerations. Ideological constraints, in relation to belief systems, can determine the specific use of individual resources or, indeed, the exploitation of landscape as a whole. The archaeological preoccupation with simply economic or utilitarian aspects of prehistoric hunter-gatherer lifeways is partly due to our own cultural attitudes. In another sense it arises from the paucity of archaeological evidence from terrestrial sites, where preservation conditions are frequently poor. The North Sea Basin presents opportunities to change perspectives with regard to the Late Palaeolithic and Mesolithic

Topic G.1: Spatial perspectives on North Sea Palaeolandscapes. The North Sea Basin is commonly perceived as a large body of water separating the British Isles from the Continent. This perspective is a natural consequence of present-day geography, and there is also an understandable tendency to use national borders to delimit research areas. Plainly, these borders did not exist for prehistoric people, nor was the North Sea Basin under water all the time. By considering the entire area and its contiguous modern landmasses as one continuous land surface with multiple characteristics that changed over time – instead of simply looking at it as a 'corridor' between the British Isles and the Continent – fresh perspectives on prehistoric lifeways can be developed.

Topic G.2: The distributional nature of early hominin communities. The appearance and disappearance of Pleistocene hominids in NW-Europe, as evidenced by the archaeological record, has usually been seen as a consequence of glacial to interglacial cycles. Population movement is thus seen as a response to changing environmental conditions: hominin communities are believed to have followed the geographically-shifting habitats to which they were best-adapted. However, in reality, very little is known about the true distribution of early hominin communities. By considering distributional patterns in a continuous framework of space and time, characterization in terms of, for example, Gorodkov's model of distributional modes may provide new insights into the very nature of occupational continuity and discontinuity.[76]

Topic G.3: Encultured hunter-gatherer landscapes. Hunter-gatherers are traditionally depicted as people who were strongly dependent on what the 'natural' environment had to offer and who had few, and then only transient, impacts on their habitats. A static classification of 'site types' and settlement systems reduces hunter-gatherer lifeways to one of a continuous struggle for survival, governed by the constraints of the 'harsh wilderness': in 19th century terms, mere savagery. However, ethno-archaeological studies among present-day hunter-gatherers demonstrate that they perceive, and give meaning to, landscapes in a highly structured way, albeit this is a cultural variable.[77] For them, there is no clear distinction between different dimensions of landscape use. Approaching the archaeological record with this perception in mind can help us to develop a more realistic understanding of relationships between early humans and their landscapes.

Strategies

Obviously, research can be initiated from various perspectives. In the context of the NSPRMF, problem-oriented or targeted research must be focused on research related to specific questions. Development-led investigations also often provide useful information, but the research dividend can only be maximised through rigorous prior assessment of resources. More proactively, it may be possible to undertake targeted research in areas where no developments are foreseen. In addition to targeted research, so-called 'curiosity-driven' research can also be valuable. The NSPRMF is not meant to be prescriptive, nor to exclude valid new lines of investigation that emerge as opportunities arise, or new insights are developed.

Priorities

1. Increasing the *understanding of the palaeogeography* of the North Sea so as to permit definition of priority areas for research and management (topics A1, A2, A3, B1, B2, B3). In the short- to medium term, enhanced palaeogeographic understanding can be achieved through new ways of interrogating existing data. There will also be opportunities for targeted additional survey and sampling in areas of interest which are being economically exploited. An example of this would be the current investigations being undertaken in the North Sea Extraction Area 240, from which Middle Palaeolithic artefacts have been recovered, with the aim of providing contextual palaeogeographic and stratigraphic information for these finds. However, there will always be some areas which will remain relatively economically unexploited, and in these areas some purposive offshore geophysical survey will be required in the longer term.

2. *Improved chronology,* based on absolute dating of *in situ* sediments, is needed so as to enable the assessment of the rate and extent of landscape development (topics A1, A2, A4). In part, improving chronology will involve an on-going compilation of dates obtained as part of archaeological mitigation at specific developments; but these may not be in the main areas of archaeological interest. In the longer term, purposive acquisition of dates from areas deemed to be of particular significance, in a palaeogeographic sense, will be required.

3. Increasing the *number of good data points* and improved *prospection techniques* for 'site' detection and characterisation. Designation of areas of special interest, from the archaeological management point of view, is unlikely to be possible unless direct evidence for human presence can be demonstrated: regulators are apt to take a highly specific view of what needs to be conserved. However, since prehistoric humans were an integral part of the landscape, palaeoenvironmental remains are of equal significance. Techniques requiring more trialling include grab-sampling and controlled use of trawls. As the use of beam trawls in the fishing industry might be discontinued within the next 5 years or so, targeted and controlled use of this technique is recommended whilst it is still possible to use it.

Notes

65 Busschers *et al.* in prep.

66 Busschers *et al.* 2007, 2008; Gibbard 2007; Gupta *et al.* 2007.

67 Weninger *et al.* 2008.

68 Gaffney, Thomson & Fitch 2007; Rieu *et al.* 2005.

69 e.g. Bailey 2004.

70 Parfitt *et al.* 2005.

71 Andersson & Knarrström 1999.

72 See Conneller (2007) for another perspective on these issues.

73 Peeters 2007, pp. 171-3.

74 E.g. Milner *et al.* 2004; Richards, Schulting & Hedges 2003.

Section 4 Resource management agenda and strategies

Attempting to manage submerged prehistoric landscapes presents difficulties that differ fundamentally from those inherent in managing the maritime cultural heritage of historic periods: the latter essentially consist of 'point elements' or local phenomena, for example wreck sites. Prehistoric landscapes are continuous in nature and much of the archaeology within them has a diffuse character due to specific formation processes, such as landscape use in relation to landscape dynamics.[78] Furthermore, the visibility of prehistoric – and by this we mean pre-Neolithic – remains is minimal, thus making detection underwater problematic but not impossible. In this section the main issues of heritage management in the context of the NSPRMF will be explored and a strategy relating to research potential will be presented with reference to (Section 2) and agenda (Section 3).

Theme H: Legislation and preservation

As outlined in Section 1, the area covered by the NSPRMF is subject to a complex legislative regime operating at a national and international level. Dutch and UK Historic Environment legislation provides a direct means of managing the archaeological heritage. International legislation is principally concerned with the regulation of economic development and its effects on the natural environment: the historic environment is only indirectly addressed. However, there are opportunities to manage prehistoric sites and landscapes within these somewhat adverse circumstances. We have to get our act together to define the potential, publicise it, and develop conservation strategies. We will not achieve this without developing a public consensus that it is worthwhile and valuable (Section J, below).

Topic H.1: Defining prehistoric cultural heritage. A significant part of the archaeological heritage in the North Sea is related to the behaviour of prehistoric hunter-gatherers. Hunter-gatherers are intimately part of the environment, yet are able to adapt their economic strategies to changing environmental conditions, within the context of their belief systems (see topics F.2 and G.3). Hence, environmental conditions define the parameters of what is *possible* behaviour, but do not *dictate* the way hunter-gatherers make use of their habitat in practice. Since hunter-gatherers functioned in prehistory, (and a few do even today), at the level of the landscape, it seems appropriate to consider them as an integral part of the landscape. In scaling up the behavioural space from settlement to landscape there is also need for a clear definition of what constitutes the prehistoric cultural heritage, in terms of archaeological manifestations of landscape use and palaeoenvironmental context. As prehistorians we have become accustomed to thinking about the early prehistoric cultural heritage in landscape terms, but we must recognise that this perception is not widespread. Also, the practical implications of this perspective in terms of heritage management have to be explored.[79]

Topic H.2: Common Ground for the protection of the historic and natural environment. The ecological lobby has been particularly successful in getting the importance of a sustainable natural environment on the agenda. 'Green' initiatives comprise for instance the creation of a European ecological network of protected areas, and this will also be embodied in the forthcoming UK Marine Act, which will establish *Marine Conservation Zones*. Most people would readily accept that this is necessary and essential. There is a real case to be made for submerged prehistoric landscapes – which embody the close relationship between our species and earlier hominids with palaeolandscapes – as something akin to endangered species. If we can present them in this way it may become easier to draw attention to the importance of the submerged historic environment. There is a need for a common language and a shift in attitudes towards the historic environment in order to create better chances for its management.

Topic H.3: Conservation of submerged prehistoric landscapes in a dynamic environment. In taking the landscape as a central concept, the question arises as to how, and indeed *whether*, we can deal with extensive areas in terms of sustainable conservation.[80] The North Sea floor is highly dynamic due to humanly and naturally induced processes, which continuously reshape the topography. Insight into the specific nature, intensity and spatial impact of these processes is central to the exploration of possibilities, or impossibilities, for long-term conservation of land surfaces.[81]

Theme I: Assessment and data sharing

Cultural heritage management in the Netherlands and in the UK takes, as a starting point, the principle of 'preservation *in situ*', but this might not always be realistic in the context of North Sea submerged prehistoric landscapes. Often it will not be possible to define particular locations, (or, to put it crudely, 'sites'), as evidence for prehistoric land use. For this reason, and given the landscape perspective on which this document is based, the main objective should therefore be the preservation of areas of landscape (see Topic H.1). The effectiveness of heritage managers in developing programmes of conservation and mitigation depends – amongst other things – on the availability of tools tailored to specific needs. These needs can be defined in terms of research potential, threats and sustainability.

Topic I.1: Research potential and threat mapping. Cultural heritage management must be underpinned by a sound knowledge base, in terms of the anticipated spatial distribution of resources. The NSPRMF covers an enormous time period, so there will be a need for developing Indicative Models of Research Potential (IMRPs), These will provide insight into the spatial distribution of features and zones relevant to defined sets of research questions. In addition, it will be necessary to develop models assessing threats from economic developments and natural processes to zones of high research potential.

Topic I.2: Surveying. Data acquisition in the field is often conducted independently for specific purposes by different sectors. Geological surveys conducted by the hydrocarbon and aggregate industries, for instance, produce enormous quantities of data[82] , as do geotechnical assessments conducted in advance of specific offshore and coastal construction works. These are costly enterprises. Unfortunately, the archaeological and palaeoenvironmental significance of such data is frequently ignored. Integrating survey at an early stage in project development, so that geological and geotechnical data acquisition contributes to archaeological assessment is highly cost-effective.

Topic I.3: Data sharing and find reporting. Artefacts and faunal and botanical materials have been, and are still being, collected by various private collectors from the North Sea, and to a lesser extent by official institutions. In particular, the quantity of palaeontological material brought ashore every year is impressive. Even though the great majority of finds are out of context, their scientific value is high. It is essential that efforts are put in archiving data on the nature and context, so far as is known, of all categories of finds. Such archives, and items themselves, must be made accessible, as they will provide the basis for future scientific analysis, and for the development of management strategies.

Topic I.4: Co-operation. Many parties are active in the North Sea 'arena': the aggregate and fishing industries extract economic resources, researchers seek to enlarge data-sets, and collectors, principally private individuals, seek more finds. The interests of these disparate groups are obviously diverse, and consequently there can be much misunderstanding. This can result in potentially valuable information being either lost or inaccessible. Actively promoting collaboration will be essential.

Theme J: Public outreach

Prehistoric aspects of the North Sea come very much as a surprise to most people, including some scientists,[83] whenever new discoveries are reported and come to the attention of the international and national media.[84] North Sea Prehistory certainly captures the public's imagination. As part of the development of management strategies for the submerged prehistoric heritage – in which the relationship between people and landscape is central – public outreach requires particular attention. Several other topics related to issues of modern day life should be considered.

Topic J.1: Changing worlds. Our modern society is faced with rapid and major changes in the environment due to climate change. Even though the 'causes' of climate change are still debated, the process itself is generally acknowledged. However, climate change also occurred in the past, and alternating glacial and interglacial conditions had impacts on the landscape, especially in the area that we know nowadays as the North Sea. As this was an inhabited area, prehistoric people would have experienced such changes to greater or lesser degree, largely depending on the rate and scale of change. The awareness that past environments, inhabited by prehistoric people and by animals which nowadays are extinct, or are confined to nature reserves or zoos, were constantly subject to change can increase the perception that our modern day environment is intrinsically dynamic.[85]

Topic J.2: 'Them' and 'us' | 'Nature' and 'Culture'. Seeing hunter-gatherers as people altogether alien to us strongly influences the appreciation of their cultural heritage, as hunter-gatherers may not be seen as our ancestors.[86] It is commonly considered that they were dependent on the 'natural' environment, and were in one sense 'natural' themselves, i.e. wild or savage. They may be seen as having contributed little to cultural development and 'civilization'. Simplistic representations of these people as living in a constant battle for survival in the harsh wilderness undervalue and diminish the complexities of hunter-gatherer environments and lifestyles. In addressing the complexities of hunter-gatherer landscape use and landscape perceptions, a contribution can be made to broader debates on cultural diversity and relationships between people and their environment.[87]

Strategies

In the context of the NSPRMF scientific research (Section 3) and heritage management (this section) are closely linked, and the two must operate together. However, it will not be possible to create an integrated research and management approach immediately. The objectives of heritage management and scientific research are not necessarily consistent, and may operate over differing time scales. It is therefore necessary to define priorities which can provide the basis for an integrated approach. In other words steps have to be taken, firstly, so as to increase recognition that the North Sea Basin is highly significant area and, secondly, to help create conditions which will foster the development and implementation of appropriate research and management strategies.

Priorities

1. Continued and improved *collaboration with industry and private collectors*. Private collectors in the Netherlands, and to some extent in the UK, have played a key role in acquiring new data points and building up scientifically significant collections. Their experience and collaboration, especially with the fishing industry, is exemplary. It will be necessary for individual national heritage agencies to forge contacts, based on mutual trust, with industry sectors hitherto neglected in their own countries. At a national level, the Aggregates Levy Sustainability Fund (ALSF) in the United Kingdom and 'Malta'-based regulation in the Netherlands provide formalised structures for financial support.

2. *Data sharing* and *spatial definition of research potential and threats* will be essential for the development of effective management strategies. Being able to show 'points on a map' is essential to highlight the scientific importance of designated areas, and hence to make most effective use of research opportunities provided by economic developments. Understanding palaeolandscape dynamics and the extent of survival of potentially informative zones is a prerequisite for the assessment of threats and hence the development of management strategies.

3. *Mitigation, conservation and designation*. Developing these measures depends upon ensuring that the prehistoric maritime historic environment receives adequate consideration in EU Directives and Recommendations, and in national legislation. Alongside attempting to ensure adequate mitigation and information gain during development, conservation of critical areas needs to be ensured as far as possible. Extensive landscape designations would probably be impossible to achieve, but relatively large-scale site-based designations might be possible. However, this could only be achieved once the requirements for priorities 1 and 2 are met.

Notes

75 Van de Noort 2004, 2006.

76 Gorodkov 1986. This ecological model defines a 'zone of continuous distribution' and a 'zone of corpse removal' at the extremes of the range of a given species, with variable degrees of clustering and dispersal in the population, resulting in differential viability to regional survival/extinction.

77 E.g. Jordan 2003.

78 Peeters 2006, 2007; Rensink, Deeben & Peeters 2006.

79 *Cf.* Peeters 2007.

80 There may be some scope for the physical protection of areas of special interest within Marine Protected Areas (designated primarily for Nature Conservation purposes under the terms of the forthcoming Marine Bill in the UK), and at least one offshore commercial developer has shown a willingness to exclude areas with demonstrable archaeology from further exploitation. However, it would be unrealistic to imagine that such protected and excluded areas could comprise more than a small proportion of the total area of the North Sea. Defining the most critical areas is thus essential. For the rest, we will be involved in a process of managing change, so as to maximise the information gain that commercial operations provide.

81 The MACHU project (launched in 2006) aims at the development of such models in a GIS environment.

82 For example, the aggregates industry is in the process of conducting Regional Environmental Assessments (REAs) for the Greater Thames and off East Anglia areas as a means of delivering a shadow Strategic Environmental Assessment. The ALSF is supporting Regional Environmental Characterisation (RECs) studies which are more broad-scale geophysical survey exercises with subsequent analysis to provide baseline information. Studies are on-going for the Solent and Thames with new surveys and studies commissioned for off East Anglia and off the Humber.

83 See, for example, the News Feature article on the Mesolithic North Sea landscape by Spinney (2008) in *Nature*.

84 For instance, the news of the discovery at a wharf at Flushing (Netherlands) of a series of Middle Palaeolithic hand axes originating from a gravel extraction area off the East Anglian coast triggered an avalange of news items in newspapers and journals (e.g. National Geographic, Science) all around the world. The number of visits to Wessex Archaeology's web pages reporting on these finds shot from c.250 each day to more than 4500 at the day of the press release, totalling over 11,000 visits from all around the world in just five days.

85 A static worldview very much characterizes the Western perception of the environment.

86 Zvelebil & Moore 2006, p. 151.

87 E.g. Descola 2005.

References

Andersson, M. & B. Knarrström, 1999: *Senpaleolitikum i Skåne*, Lund (RAA Arkeoliska undersökningar Skrifter No. 26).

Bailey, G., 2004: The wider significance of submerged archaeological sites and their relevance to world prehistory, in: N.C. Flemming (ed.): *Submarine prehistoric archaeology of the North Sea: research priorities and collaboration with industry*, York (CBA Research Report 141), 3-10.

Behre, K.-E. 2007, A new Holocene sea-level curve for the southern North Sea. *Boreas* 36: 82-102.

Bell, M., 2007, *Prehistoric Coastal Communities: the Mesolithic in Western Britain*, York (Council for British Archaeology Report 149).

Bell, M. & M.J.C. Walker, 2005: *Late Quaternary environmental change (2nd edition)*, Harlow.

Bell, M., C. Chisham, P. Dark & S. Allen, 2006: Mesolithic sites in coastal and riverine contexts in southern Britain: current research and the management of the archaeological resource, in: E. Rensink & H. Peeters (eds.), *Preserving the early past. Investigation, selection and preservation of Palaeolithic and Mesolithic sites and landscapes*, Amersfoort (Nederlandse Archeologische Rapporten 31), 25-39.

Bos, J.A.A. & C.R. Janssen, 1996: Local impact of Palaeolithic Man on the environment during the end of the Last Glacial in the Netherlands. *Journal of Archaeological Science* 23, 731-739.

Bos, J.A.A. & R. Urz, 2003: Late Glacial and Early Holocene environment in the middle Lahn river valley (Hessen, central-west Germany) and the local impact of Early Mesolithic man — pollen and macrofossil evidence. *Vegetation History and Archaeobotany* 12, 19-36.

Bos, J.A.A., B. van Geel, B.J. Groenewoudt & R.C.G.M. Lauwerier, 2005: Early Holocene environmental change, the presence and disappearance of early Mesolithic habitation near Zutphen (The Netherlands). *Vegetation History and Archaeobotany* 15, 27-43.

Brown, N. & J. Glazebrook (eds.), 2000: Research and Archaeology: a framework for the Eastern Counties. 2. Research Agenda and Strategy. *East Anglian Archaeology Occasional Paper* 8.

Busschers, F.S, C. Kasse, R.T. van Balen, J. Vandenberghe, K.M. Cohen, H.J.T. Weerts, J. Wallinga, C. Johns, P. Cleveringa & F.P.M. Bunnik, 2007: Late Pleistocene evolution of the Rhine-Meuse system in the southern North Sea basin: imprints of climate change, sea-level oscillation and glacio-isostasy. *Quaternary Science Reviews* 26, 3216-48.

Busschers, F.R., R.T. van Balen, K.M. Cohen, C. Kasse, H.J.T. Weerts, J. Wallinga & F.P.M. Bunnik, 2008: Response of the Rhine-Meuse fluvial system to Saalian ice-sheet dynamics. *Boreas* 37, 377-98.

Busschers, F.R. *et al.* in prep.: Radiocarbon ghost dates from Late Pleistocene North Sea marine molluscs. (To be submitted).

Cohen, K.M., 2005: 3D geostatistical interpolation and geological interpretation of palaeo-groundwater rise in the Holocene coastal prism in the Netherlands, in: L. Giosan & J.P. Bhattacharya, *River Deltas - concepts, models and examples*, (SEPM Special Publication 83), 341-64.

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

Conneller, Ch., 2007: Inhabiting new landscapes: settlement and mobility in Britain after the last glacial maximum. *Oxford Journal of Archaeology* 26, 215-37.

Dark, P., 1998: Interpretation of the lake-edge sequences, in: P. Mellars & P. Dark (eds.): *Star Carr in context: new archaeological and palaeoecological investigations at the Early Mesolithic site of Star Carr, North Yorkshire*, Oxford.

Darvill, T. (ed.), 2005: *Stonehenge World Heritage Site. An archaeological research framework*, London/Bournemouth.

Deeben, J.H.C. (ed.): *De Indicatieve Kaart van Archeologische Waarden, derde generatie*, Amersfoort (Rapportage Archeologische Monumentenzorg 155).

Deeben, J., D.P. Hallewas & Th.J. Maarleveld, 2002: Predictive modelling in archaeological heritage management of the Netherlands: the indicative map of archaeological values (2nd generation), *Berichten Rijksdienst voor het Oudheidkundig Bodemonderzoek* 45, 9-56.

Deeben, J., H. Peeters, D. Raemaekers, E. Rensink & L. Verhart, 2006: De vroege prehistorie. Chapter 11, in: *Nationale Onderzoeksagenda Archeologie* (www.noaa.nl).

Descola, Ph., 2005: *Par-delà nature et culture*, Paris (Bibliothèque des Sciences Humaines).

Fischer, A., 2004: Submerged Stone Age — Danish examples and North Sea potential, in: N.C. Flemming (ed.): *Submarine Prehistoric archaeology of the North Sea: research priorities and collaboration with industry*, York (CBA Research Report 141), 21-36.

Fitch, S., K. Thomson & V.L. Gaffney, 2005: Late Pleistocene and Holocene depositional systems and palaeogeography of the Dogger Bank, North Sea. *Quaternary Research* 64, 185-96.

Flemming, N.C., 2002: *The scope of Strategic Environmental Assessment of North Sea areas SEA3 and SEA2 in regard to prehistoric archaeological remains*. (SEA3_TR014. Department of Trade and Industry).

Flemming, N.C. (ed.), 2004: *Submarine prehistoric archaeology of the North Sea: research priorities and collaboration with industry*, York (CBA Research Report 141).

Gaffney, V.L., K. Thomson & S. Fitch (eds.), 2007: *Mapping Doggerland: The Mesolithic Landscapes of the Southern North Sea*, Oxford.

Gaffney, V.L., S. Fitch & D. Smith, 2009: *Europe's lost world. The rediscovery of Doggerland*, York (CBA Research Report 160).

Gibbard, P.L., 1995: Formation of the Strait of Dover, in: R.C. Preece (ed.), *Island Britain - a Quaternary perspective.* Geological Society Special Publication 96, 15-26.

Gibbard, P.L., 2007: Europe cut adrift. *Nature* 448, 7151, 259-60.

Gibbard, P.L. & K.M. Cohen, 2008: Global chronostratigraphical correlation table for the last 2.7 million years. *Episodes*, 31, 243-7.

Gijssel, K. van, 2006: *A continent-wide framework for local and regional stratigraphies. Application of genetic sequence and event stratigraphy to the Middle Pleistocene terrestrial succession of Northwest and Central Europe*, Leiden (unpublished thesis).

Glazebrook, J. (ed.), 1997: Research and Archaeology: a framework for the Eastern Counties, 1. Resource Assessment. *East Anglian Archaeology Occasional Paper* 3.

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

Glimmerveen, J., D. Mol & H. van der Plicht, 2006: The Pleistocene reindeer of the North Sea — initial palaeontological data and archaeological remarks. *Quaternary International* 142/143, 242-6.

Glimmerveen, J., 2007: Fish and stones. *North Sea Prehistory Newsletter* 1, 9-10.

Gorodkov, K.B., 1986: Three-dimensional climatic model of potential range and some of its characteristics II. *Entomological Review* 65, 1-18.

Gupta, S., J.S. Collier, A. Palmer-Felgate & G. Potter, 2007: Catastrophic flooding of shelf valley systems in the English Channel. *Nature* 448, 7151, 342-6.

Hansen, J.S., 1981: *Naturegasprojektet og de Marinarkæologiske Forundersøgelser*, Copenhagen.

Hazell, Z. J., 2008: Offshore and intertidal peat deposits, England: a resource assessment and development of a database. *Environmental Archaeology*, 13, 101-10.

Houtgast, R.F., R.T. van Balen & C. Kasse, 2005: Late Quaternary evolution of the Feldbiss Fault (Roer Valley Rift System, the Netherlands) based on trenching, and its potential relation to glacial unloading. *Quaternary Science Reviews* 24, 489-508.

Hublin, J.-J., D. Weston, Ph. Gunz, M. Richards, W. Roebroeks, J. Glimmerveen & L. Anthonis, in press: Out of the North Sea: the Zeeland Ridges Neandertal. *Journal of Human Evolution*.

Jelgersma, S., 1979: Sea-level changes in the North Sea Basin, in: E. Oele, R.T.E. Schuttenheim & A.J. Wiggers (eds.): *The Quaternary History of the North Sea*, Uppsala (Acta Universitatis Upsaliensis), 233-48.

Jordan, P., 2003: *Material culture and sacred landscape. The anthropology of the Siberian Khanty*, Walnut Creek.

Kars, R.H., J. Wallinga & K.M. Cohen, 2008: A new approach towards anomalous fading correction for feldspar IRSL dating – tests on samples in field saturation. *Radiation Measurements* 43, 786-90.

Kiden, P., L. Denys & P. Johnston, 2002: Late Quaternary sea-level change and isostatic and tectonic land movements along the Belgian-Dutch North Sea coast: geological data and model results. *Journal of Quaternary Science* 17, 535-46.

Laban, C., 1995: *The Pleistocene glaciations in the Dutch sector of the North Sea. A synthesis of sedimentary and seismic data*, Amsterdam (unpublished dissertation).

Laban, C., Cameron, T.D.J. & R.T.E. Schüttenheim, 1984: Geologie van het Kwartair in de zuidelijke bocht van de Noordzee. *Mededelingen van de Werkgroep voor Tertiaire en Kwartaire Geologie* 21, 139-54.

Lambeck, K., A. Purcell, S. Funder, K.H. Kjær, E. Larsen & P. Möller, 1996: Constraints on the Late Saalian to early Middle Weichselian ice sheet of Eurasia from field data and rebound modelling. *Boreas* 35, 539-75.

Lanting, J.N., 1998: Dates for origin and diffusion of the European logboat, *Palaeohistoria* 39/40, 627-50

Louwe Kooijmans, L.P., 1970/71: Mesolithic bone and antler implements from the North Sea and from the Netherlands. *Berichten Rijksdienst voor het Oudheidkundig Bodemonderzoek* 20/21, 27-73.

Maarleveld, Th.J., 1984: *1983. Derde jaar archeologie in Nederlandse wateren*, Rijswijk.

Menot, G., E. Bard, F. Rostek, J.W.H. Meijers, E.C. Hopmans, S. Schouten & J.S. Sinninghe Damsté 2006: Early reactivation of European rivers during the last deglaciation. *Science* 313, 1623–5.

Milner, N., Craig, O.E., Bailey, G.N., Pedersen, K. & Andersen, S.H., 2004: Something fishy in the Neolithic? A re-evaluation of stable isotope analysis of Mesolithic and Neolithic coastal populations, *Antiquity* 78, 9-22.

Mol, D., K. Post, J.W.F. Reumer, J. van der Plicht, J. de Vos, B. van Geel, G. van Reenen, J.-P. Pals & J. Glimmerveen, 2006: The Eurogeul — first report of the palaeontological, palynological and archaeological investigations of this part of the North Sea. *Quaternary International* 142/143, 178-85.

Mulder, E.F.J. de, M.C. Geluk, I. Ritsema, W.E. Westerhoff & T.E. Wong (eds.), 2005: *De ondergrond van Nederland*, Groningen.

Murphy, P., 2007: The submerged prehistoric landscapes of the southern North Sea: work in progress. *Landscapes* 2007-1, 1-22.

Noort, G. van & A. Wouters, 1987: De jagers-verzamelaars van de Ahrensburgcultuur. *Archaeologische Berichten* 18, 63-138.

Noort, R. van de, 2004: *The Humber Wetlands; the archaeology of a dynamic landscape*. Windgather Press

Noort, R. van de, 2006: Ancient Seascapes: the social context of seafaring in the Bronze Age, *World Archaeology* 35 (3), 404-15.

Oosting, R. & M. Manders (eds.), 2007: *MACHU Report 1*, Rotterdam.

Parfitt, S.A., R.W. Barendregt, M. Breda, I. Candy, M.J. Collins, G.R. Coope, P. Durbidge, M.H. Field, J.R. Lee, A.M. Lister, R. Mutch, K.E.H. Penkman, R.C. Preece, J. Rose, C.B. Stringer, R. Symmons, J.E. Whittaker, J.J. Wymer & A.J. Stuart, 2005: The earliest record of human activity in northern Europe, *Nature* 438, 1008-12.

Peeters, H., 2006: Sites, landscapes and uncertainty: on the modelling of the archaeological potential and assessment of deeply buried Stone Age landscapes in the Flevoland polders (the Netherlands), in: E. Rensink & H. Peeters (eds.), *Preserving the early past. Investigation, selection and preservation of Palaeolithic and Mesolithic sites and landscapes*, Amersfoort (Nederlandse Archeologische Rapporten 31), 167-84.

Peeters, J.H.M., 2007: *Hoge Vaart-A27 in context: towards a model of Mesolithic-Neolithic land use dynamics as a framework for archaeological heritage management*, Amersfoort.

Peltier, W.R., 2004: Global glacial isostacy and the surface of the Ice-Age Earth: The ICE-5G (VM2) model and GRACE. *Annual Review of Earth and Planetary Sciences* 32, 111-49.

Pettitt, P., C. Gamble & J. Last (eds.), 2008: *Research and conservation framework for the British Palaeolithic*, London.

Pieters, M., I. Demerre, T. Lenaerts, I. Zeebroek, M. De Bie, W. De Clercq, B. Dickinson & P. Monsieur, in press: De Noordzee: een waardevol archief onder water. Meer dan 100 jaar onderzoek van strandvondsten en vondsten uit de zee in België: een overzicht. *Relicta, Archeologie, monumenten- en landschapsonderzoek in Vlaanderen 6*.

Plicht, J.van der, J.W. Beck, E. Bard, M.G.L. Baillie, P.G. Blackwettl, C.E. Buck, M. Friedrich, T.P. Guilderson, K.A. Hughen, B. Kromer, F.G. McCormac, C.Bronk Ramsey, P.J.Reimer, R.W. Reimer, S. Remmele, D.A. Richards, J.R. Southon, M. Stuiver, C.E.Weyhenmeyer, 2004: NOTCAL04: comparison / calibration ^{14}C records 26-50 cal kyr BP. *Radiocarbon* 46, 1225-38.

Reid, C., 1913: *Submerged forests*, Oxford.

Rensink, E., J. Deeben & H. Peeters, 2006: Early prehistoric sites and landscapes in the Netherlands. Building frameworks for archaeological heritage management, in: E. Rensink & H. Peeters (eds.), *Preserving the early past. Investigation, selection and preservation of Palaeolithic and Mesolithic sites and landscapes*, Amersfoort (Nederlandse Archeologische Rapporten 31), 201-26.

Richards, M.P., R.J. Schulting & R.E.M. Hedges, 2003: Sharp shift in diet at onset of Neolithic. *Nature* 425, 366.

Rieu, R., S. van Heteren, A.J.F. van der Spek & P.L. de Boer, 2005: Development and preservation of a mid-Holocene tidal channel network offshore the western Netherlands. *Journal of Sedimentary Research* 75, 409-19.

Roep, T.B., H. Holst, R.L.M.Vissers, H. Pagnier & D. Postma, 1975: Deposits of southward-flowing, Pleistocene rivers in the Channel region, near Wissant, N.W. France. Palaeogeography, Palaeoclimatology, Palaeoecology 17, 289–308.

Schokker, J., P. Cleveringa, A.S. Murray, J. Wallinga & W.E. Westerhof, 2005: An OSL dated Middle and Late Quaternary sedimentary record in the Roer Valley Graben (southeastern Netherlands). *Quaternary Science Reviews* 24, 2243-64.

Seel, S., 2000: 'The Erith Buried Forest', in Long, A. and Sidell, J. (eds), *IGCP 437: Coastal Environmental Change During Sea-Level High Stands: The Thames Estuary. Field Guide*, Durham, (University of Durham Research Publication 4), 33-9.

Shennan, I., S. Bradley, G. Milne, A. Brooks, S. Bassett & S. Hamilton, 2006: Relative sea-level changes, glacial isostatic modelling and ice-sheet reconstructions from the British Isles since the Last Glacial Maximum. *Journal of Quaternary Science* 21, 585-99.

Simmons, I.G., 1993: Vegetation change during the Mesolithic in the British Isles: some amplifications, in: F.M. Chambers (ed.): *Climate change and human impact on the landscape*, London, 109-118.

Smith, A.J., 1985: A catastrophic origin for the palaeovalley system of the eastern English Channel. *Marine Geology* 64, 65-75.

Spinney, L., 2008: The Lost World. *Nature* 454, 7201, 151-3.

Steffen, H., 2006: *Determination of a consistent viscosity distribution in the earth's mantle beneath northern and central Europe*, Berlin (dissertation Free University).

Vera, F., 1997: *Metaforen voor de wildernis. Eik, hazelaar, rund en paard*, 's-Gravenhage.

Verhart, L.B.M., 1988: Mesolithic barbed points and other implements from Europoort, the Netherlands. *Oudheidkundige Mededelingen uit het Rijksmuseum van Oudheden* 68, 145-194.

Verhart, L.B.M., 1995: Fishing for the Mesolithic. The North Sea: a submerged Mesolithic landscape, in: A. Fischer (ed.): *Man and sea in the Mesolithic, coastal settlement above and below present sea level*, Oxford, 291-302.

Verhart, L., 2004: The implications of prehistoric finds on and off the Dutch coast, in: N.C. Flemming (ed.): *Submarine prehistoric archaeology of the North Sea: research priorities and collaboration with industry*, York (CBA Research Report 141), 57-61.

Vink, A., H. Steffen, L. Reinhardt & G. Kaufmann, 2007: Holocene relative sea-level change, isostatic subsidence and the radial viscosity structure of the mantle of northwest Europe (Belgium, the Netherlands, Germany, southern North Sea). *Quaternary Science Reviews* 26, 3249–75.

Wallinga, J., 2002: Optically stimulated luminescence dating of fluvial deposits: a review. *Boreas* 31, 303-22.

Ward, I., P. Larcombe & M. Lillie, 2006: The dating of Doggerland — post-glacial geochronology of the southern North Sea. *Environmental archaeology* 11-2, 207-18.

Ward, I. & P. Larcombe, 2008: Determining the preservation rating of submerged archaeology in the post-glacial southern North Sea: a first-order geomorphological approach. *Environmental Archaeology* 13, 59-83.

Weerts, H.J.T., P. Cleveringa, J.H.J. Ebbing, F.D. de Lang & W.E. Westerhoff, 2000: *De lithostratigrafische indeling van Nederland; Formaties uit het Tertiair en Kwartair*, Utrecht (TNO-rapport 00-95-A).

Wenban-Smith, F., 2003: *Palaeolithic and Mesolithic archaeology on the sea bed: marine aggregate dredging and the historic environment*, Southampton.

Weninger, B., R. Schulting, M. Bradtmöller, L. Clare, M. Collard, K. Edinborough, J. Hilpert, O. Jöris, M. Niekus, E.J. Rohling & B. Wagner, 2008: The catastrophic flooding of Doggerland by the Storegga Slide tsunami. *Documenta Praehistorica* XXXV, 1-24.

Williams, J. & N. Brown (eds.), 1997: *An archaeological research framework for the Greater Thames Estuary* (Essex CC/Kent CC/English Heritage/Thames Estuary Partnership).

Wiltenburg, D., 1980: Vondstmelding van een vindplaats uit het Midden-Acheuleen uit de Noordzee. *Archaeologische Berichten* 9, 98-103.

Zagwijn, W.H., 1989: The Netherlands during the Tertiary and Quaternary: a case history of coastal lowland evolution. *Geologie en Mijnbouw* 68, 107-20.

Zagwijn, W.H. & C.J. Van Staalduinen (eds.), 1975: *Toelichtingen bij de geologische overzichtskaarten van Nederland*, Haarlem, 1-134.

Zvelebil, M. & J. Moore, 2006: Assessment and representation: the information value of Mesolithic landscapes, in: E. Rensink & H. Peeters (eds.), *Preserving the early past. Investigation, selection and preservation of Palaeolithic and Mesolithic sites and landscapes*, Amersfoort (Nederlandse Archeologische Rapporten 31), 151-65.

Smith, D.E., P.T. Fretwell, R.A. Cullingford, & C.R. Firth, 2006: Towards improved empirical isobase models of Holocene land uplift for mainland Scotland, UK. *Philosophical Transactions of the Royal Society of London, Series A*, 364, 949-72.

Smith, D.E., N. Hunt, C.R. Firth, P.T. Fretwell, M. Harman, J. Murdy, J.D. Orford & J.T. Jordan, 2007: Glacio-isostatic uplift and sea surface changes during the last 8000 years in the United Kingdom and the Republic of Ireland. *Quaternary International* 167-168, supplement 1, 391.

Colophon

North Sea Prehistory Research and Management Framework (NSPRMF) 2009

Editors:
Hans Peeters, Peter Murphy, Nic Flemming

Contributors
Dr Kim Cohen *Utrecht University, The Netherlands*
Dr Antony Firth *Wessex Archaeology, United Kingdom*
Dr Nic Flemming *Southampton National Oceanography Centre, United Kingdom*
Prof. Vince Gaffney *University of Birmingham, United Kingdom*
Dr Bas van Geel *University of Amsterdam, The Netherlands*
Mr Jan Glimmerveen *The Netherlands*
Dr Sytze van Heteren *Deltares, The Netherlands*
Prof. Thijs van Kolfschoten *Leiden University, The Netherlands*
Dr Piers Larcombe *CEFAS Lowestoft, United Kingdom*
Dr Jonathan Last *English Heritage, United Kingdom*
Mr Martijn Manders *Cultural Heritage Agency, The Netherlands*
Mr Dick Mol *Natural History Museum Rotterdam, The Netherlands*
Mr Garry Momber *Hampshire and Wight Trust for Marine Archaeology, United Kingdom*
Mr Peter Murphy *English Heritage, United Kingdom*
Ms Andrea Otte *Cultural Heritage Agency, The Netherlands*
Prof. Robert van de Noort *University of Exeter, United Kingdom*
Dr Hans Peeters *Cultural Heritage Agency / University of Groningen, The Netherlands*
Dr Paul Pettitt *University of Sheffield, United Kingdom*
Prof. Hans van der Plicht *University of Groningen / Leiden University, The Netherlands*
Mr Klaas Post *Natural History Museum Rotterdam, The Netherlands*
Prof. Jelle Reumer *Natural History Museum Rotterdam / Utrecht University, The Netherlands*
Prof. Wil Roebroeks *Leiden University, The Netherlands*
Dr John de Vos *Naturalis Leiden, The Netherlands*
Dr Ingrid Ward *United Kingdom*
Dr Henk Weerts *Cultural Heritage Agency, The Netherlands*

Acknowledgements:
The writing of this document has benefited from discussions with the following colleagues: Mr. Luc Amkreutz, Prof. Geoff Bailey, Prof. Martin Bell, Dr Freek Busschers, Dr Justin Dix, Mr Simon Fitch, Prof. Phil Gibbard, Prof. Jan Kolen, Dr Harald Lübke, Prof. Friedrich Lüth, Mr. Nigel Nayling, Mr Peter Stassen, Dr Clive Waddington. We thank Monika Lowerre and Ole Grøn for their translations of the German and Danish summaries.

Cover design: Studio Imago, Amersfoort, The Netherlands

Layout: Studio Imago, Amersfoort, The Netherlands

ISBN 978 90 5799 149 3

If you would like this document in a different format, please contact our Customer Services department:
Telephone: 0870 333 1181
Fax: 01793 414926
Textphone: 01793 414878
E-mail: customers@english-heritage.org.uk