

The southern North Sea and the human occupation of northwest Europe after the Last Glacial Maximum

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Abstract

This paper discusses the significance of the southern North Sea for research on the human occupation of northwest Europe after the Last Glacial Maximum (LGM). Recent insight into the survival of post-LGM land surfaces and palaeolandscape structures points to the potential preservation of Late Palaeolithic and Mesolithic sites in this area. Finds of well-preserved materials (including artefacts of bone, antler and wood, as well as human remains) from various zones along the Dutch and British coasts corroborate this idea, whilst underwater excavations of eroding sites at Bouldnor Cliff (UK) and Maasvlakte-Rotterdam (NL) underpin the possibilities of gaining further insight into human behaviour in the context of submerging landscapes. Although the significance of the southern North Sea with regard to the Mesolithic is gradually exposed, there is still a lot to learn. The terrestrial archaeological records from both sides of the present-day North Sea yield indisputable evidence for hunter-gatherer presence from at least 13,000 BP. Successions of Magdalenian/Creswellian/Hamburgian, Federmesser Gruppen and Ahrensburgian people (re)colonised the northwest European plain, interrupted by short-lived cold spells. Although it is expected that the southern North Sea must have been inhabited, and maybe even more intensively than the present-day dry land, archaeological evidence is still missing. Despite the presence of vast amounts of mammalian remains and the availability of many radiocarbon-dated bones, there is a striking lack of material post-dating the LGM and pre-dating the Holocene, whilst remains dated to the early Upper Palaeolithic show no evidence of human interference. At this stage, it is probable that taphonomic factors and research biases are responsible for this picture. This marks a sharp contrast with the early Holocene record, where numerous Mesolithic artefacts, as well as human remains, provide evidence for human occupation of the area. Materials are exposed on the sea floor, evidencing gradual erosion of early Holocene land surfaces. Although the number of sites is increasing, little is known yet about how the submerged record can be connected to the terrestrial record. Indeed, the central question here is how the submerged Mesolithic record compares to, or differs from, the terrestrial record. In order to answer this question, targeted archaeological research is needed, along with an understanding of taphonomic processes and increased insight into landscape dynamics. From a northwest European perspective, the present state of knowledge about the submerged post-LGM prehistoric archaeology of the southern North Sea demonstrates its huge research potential.

Keywords: Last Glacial Maximum, Late Palaeolithic, Mesolithic, North Sea, site taphonomy

Introduction

The southern North Sea basin has long played an important role in many studies concerning the recolonisation of northwest Europe after the Last Glacial Maximum (LGM) (Housley et al., 1997) and the subsequent uses of the landscape in the course of the Late Palaeolithic through Neolithic (e.g. Arts, 1988; Deeben, 1988; Baales, 1996; Coles, 1998). Largely based on coarse-grained geological data and palaeolandscape reconstructions, questions arose with regard to the importance of the North Sea area in the seasonal

migration of, for instance, the Ahrensburgian reindeer-hunters (Arts, 1988; Baales, 1996). More recently, Grøn (2005) referred to the North Sea as a potentially important area for Hamburgian reindeer-hunters, as he postulates reindeer migratory routes along the rivers that were flowing through the Late Glacial landscape. However, direct evidence for Late Palaeolithic human presence in the North Sea area is nearly absent. The situation appears somewhat better for the earlier Holocene, as finds of Mesolithic artefacts trawled-up by fishermen made clear that people were once living in the area known to us as the North Sea (Louwe Kooijmans,

1971). Bryony Coles' 1998 survey of the southern North Sea evidence led her to postulate 'Doggerland' as an integral, and possibly very important, part of the Mesolithic landscape. Indeed, as more systematic collection of artefacts and palaeontological remains has taken place (Glimmerveen et al., 2004, 2006; Mol et al., 2006), and innovative GIS techniques have exposed the palaeogeographical features of the Holocene age (Gaffney et al., 2007), there is mounting evidence to support Coles' idea.

Hitherto, most of the research has put a strong emphasis on the landscape evolution of the North Sea basin (Reid, 1913; Clark, 1936; Louwe Kooijmans, 1971; Coles, 1998). This is not only true for studies concerned with the North Sea area itself, but also for studies that attempt to interpret spatial and temporal patterns of occupation on the present-day dry land. The post-glacial drowning of Doggerland as a consequence of rising sea levels, for instance, is considered by many to have triggered increasing population densities, territoriality, sedentism and complex social behaviour (e.g. Waddington 2007a; Gaffney et al., 2009; Momber, 2011). Indeed, one may argue, the understanding of landscape dynamics is – at the very least – one crucial factor to consider in any effort to explain the patterning in the archaeological record. This is particularly so in the case of hunter-gatherers, whose behaviour can only be understood at a landscape scale (Zvelebil et al., 1992; Roebroeks, 2006; Peeters, 2007). What is relevant, then, in reference to the North Sea, is the twofold question of how the area formed an integral part of hunter-gatherer landscapes after the LGM, and how processes in this landscape affected the prehistoric uses of present-day terrestrial northwest Europe.

In this paper we seek to provide answers to some interrelated questions in order to identify the significance of the North Sea. In other words, what can we expect to learn from the area known as the North Sea? Our focus will be to answer the following questions: How is the North Sea geographically positioned in the context of the hunter-gatherer occupation history of northwest Europe after the LGM? What current, direct archaeological evidence exists for the human use of the North Sea area? How can patterns in this record be explained in relation to landscape evolution and taphonomic factors? What are our expectations with regard to the survival of records that are essential for the understanding of prehistoric hunter-gatherer behaviour at the broader landscape scale? In other words, what is the research potential?

The North Sea in the northwest European context

The North Sea, in conjunction with Britain, Belgium, the Netherlands, northern Germany and Denmark, is often portrayed as the very northern margin of the earliest expansion of anatomically modern humans. As far as can be observed from the archaeological record, Upper Palaeolithic occupation (Aurignacian, Gravettian) of northwest Europe seems to have been thin prior to the LGM (Roebroeks, 2000, 2014). Since the onset of

the LGM, northwest Europe has been deserted, and it took about 10,000 years before Magdalenian hunter-gatherers recolonised the territory. The archaeological record suggests a more structural presence of Late Palaeolithic hunter-gatherer populations (Magdalenian/Creswellian/Hamburgian, Federmesser Gruppen, Ahrensburgian) ever since, possibly inducing the emergence of some regional differentiation, although some differences may be partly explained from taphonomical processes (see below).

At the time of Magdalenian initial recolonisation (~13,000 BP), the North Sea basin, again, was in the zone of the occasional presence of hunter-gatherer groups. A small number of sites recorded in the limits of the loess belt in the southeastern part of the Netherlands represent the most northern occurrences of the late Magdalenian (Arts & Deeben, 1987; Rensink, 2010). The 'classic' Magdalenian seems to be absent outside the loess zone of continental northwest Europe, as it is in Britain. In this zone, however, the Hamburgian and Creswellian have been defined. The Hamburgian is generally characterised as a subgroup of the Magdalenian, and is identified in the northern Netherlands, northern Germany and extending to Poland. In addition to a number of English sites, including Hengistbury Head, the recent discovery of a Hamburgian site at Howburn, Scotland, has extended its geographical occurrence westward (Ballin et al., 2010). Some Hamburgian implements have furthermore been reported from Skåne, Sweden (Andersson & Knarrström, 1999). As to the affinities of the Creswellian, which is mainly identified in Britain and to a limited extent the Netherlands, there has been considerable debate (Jacobi, 1991). Barton et al. (2003), however, considered the Creswellian to be Final Magdalenian.

What is of importance here, however, is the fact that the Magdalenian 'range' (i.e. Magdalenian/Creswellian/Hamburgian) extended well into the North, and that three interrelated techno-complexes theoretically 'meet' in the North Sea basin, roughly between 13,000 and 12,000/11,500 BP. Both Jacobi (1991) and Keeley (1991) have drawn attention to the fact that the contemporary coastlines are now under water, and suggested that we have lost 'the areas of densest and most continuous settlement' (Jacobi, 1991, p.137). With sea levels about 70–80 m lower than today, the contemporary coasts have to be sought far in the North Sea and Channel/Manche (see Cohen et al., 2014). Indeed, one may wonder to what extent the northwest European Magdalenian/Creswellian/Hamburgian represent an inland range of landscape use. Notwithstanding the technological similarities, regional variability can be recognised at the level of resource exploitation and settlement, e.g. in the Paris Basin, Ardennes and Rhineland (Audouze & Enloe, 1991; Street, 1998; Rensink, 2010). From this perspective, then, an important question has to be, what happened in the North Sea area? Did large herds of reindeer traverse the river valleys (cf. Grøn, 2005), and did this attract hunter-gatherers? Was it, as Jacobi (1991) and Keeley (1991) believe, a relatively densely populated area that saw continuous settlement along the coast? Were the coastal zones exploited

differently, giving way to the development of more complex hunter-gatherers (cf. Keeley 1991, p. 188), and subsequent diversification in group identity, as can be seen among (near-) present-day coastal hunter-gatherers (Kelly 1995)?

In a way, much of what counts for the Magdalenian range also applies to the subsequent Federmesser settlement between 12,000/11,500 and 11,000 BP. Temporarily slowed down by the Dryas 2 cold spell, sea levels continued to rise at the time of the Federmesser occupation, which is mainly correlated to the Alleröd interstadium. Nonetheless, at ~60 m below sea level, the contemporary coast was still far off the present-day coast line. Hence, the archaeological evidence from continental northwest Europe and Britain can be considered to represent an inland range of landscape use. The Federmesser Gruppen, as it is currently defined, covers an area spanning from Britain to the Ukraine, and from northern France/the Alps to Denmark and possibly southern Sweden.

Despite the vast number of sites, remarkably little is known with respect to the use of the landscape, mainly due to taphonomic processes (see below). As far as can be concluded from the few sites that produced faunal remains (e.g. Bedburg-Königshoven, Germany, and Doetinchem and Wierden, the Netherlands), the Federmesser hunter-gatherers exploited a broad range of animal resources, including a variety of mammals (elk, red deer, roe deer, horse, auroch, wild boar), fowl (goose) and fish (pike) (Street, 1998; Baales, 2002; Lauwrier & Deeben, 2011). In the sandy plain of the Low Countries, sites are frequent along the western and northern shores of lakes, as well as on river terraces (Deeben, 1988; de Bie & Caspar, 2000). The British and German records show a comparable picture, albeit from a very limited sample of sites, with the addition of caves and short-lived uses of the forested inland (Elburg & van der Kroft, 1997; Street et al., 2001). A number of site types can be discerned (cf. Stapert, 1985): isolated projectile points, flint knapping sites, small special-purpose camps, multi-purpose dwelling sites and extended complexes that could relate to the contemporaneous use of several dwelling structures where people aggregated for some time (de Bie & Caspar, 2000). The latter interpretation is, however, not undisputed, as there is the possibility of repetitive site use and palimpsest formation. In the case of Niederbieber, Germany, for instance, Baales (2004) has presented evidence for frequent and rather short-lived dwelling episodes, indicating high mobility among Federmesser hunter-gatherers as opposed to the Magdalenian.

In many aspects, the Federmesser settlement of northwest Europe is somewhat comparable to the Early Mesolithic: the broad-spectrum exploitation of animal resources, the variability in settlement locations and site types, and the repeated use of specific places, leading to the formation of extended palimpsests. This raises the question of how Federmesser

hunter-gatherers used the North Sea area, where several large lakes must have been present (Gaffney et al., 2009). Could larger aggregation settlements, which we seem to 'miss' in the archaeological record, be present on the shores of these large lakes?¹ Or have concentrations of people been present in the coastal zones, in a way comparable to what can be seen for the Late Mesolithic?

The Dryas 3 cold spell brought the favourable conditions of the Alleröd to an end, leading to an open landscape in which the dominant western winds had free play. Sea level was still ~50 m lower than today, and the contemporaneous shore was far off the present-day North Sea coasts (Cohen et al., 2014). As the polar conditions were of a very short nature, Ahrensburgian hunter-gatherers would soon exploit the landscape, in which large herds of reindeer were present. While the Ahrensburgian occurs in Belgium, the Netherlands and northern Germany (Rensink et al., 1996; Jöris & Thissen, 1997), related and contemporaneous Bromme hunter-gatherers were present in the south Scandinavian territory (Andersson & Knarrström, 1999). In Britain, the 'long-blade tradition', synonymous with the Ahrensburgian, is considered to be of comparable date (Barton, 1998). As this was the case for the Magdalenian range, the North Sea basin, again, seems to be the meeting zone of these so-called tanged-point technocomplexes.

Several authors have attributed a significant role to the North Sea area, in particular with regard to Ahrensburgian hunting strategies and mobility (Arts & Deeben, 1981; van Noort & Wouters, 1987; Arts, 1988; Baales, 1999). The river valleys and larger lakes in particular will have been attractors for game and humans. Baales (1999), for instance, proposed a model in which the Ardennes formed the spring territory for Ahrensburgian hunter-gatherers, while the sandy plains of the Low Countries, northern Germany and the North Sea area formed the major hunting grounds in winter. However, our knowledge on migratory patterns of reindeer during the Late Glacial is, as yet, limited. In this respect, the reindeer remains from the North Sea (Glimmerveen et al., 2006) are of major importance (see below for further discussion). If reindeer was an important resource to the Ahrensburgian (and related technocomplexes), it is necessary to understand the relationships between reindeer habitats and Ahrensburgian hunting strategies. Ahrensburgian technology persisted into the Preboreal (Deeben et al., 2000), but would eventually be replaced by full Mesolithic micro-blade technologies. To what extent, then, does this relate to changes in the palaeoenvironmental setting?

In addition to questions about the scale of Late Glacial hunter-gatherer landscapes, migratory patterns and the exploitation of resources, the North Sea takes an important position with regard to questions about environmental diversity. Large parts of the Late

1 Note that the archaeological identification of aggregation settlements is highly problematic due to severe restrictions with respect to the possibility of establishing 'absolute' synchronicity among spatially isolated occurrences of archaeological remains. Ethnographical sources demonstrate the enormous extent over which contemporaneous dwellings in aggregation settlements can be spread, with major differences in the density of archaeologically traceable remains.

Glacial landscape are now covered with North Sea water. What did the palaeogeographical layout of northwest Europe look like, and how did it change in the course of the Late Palaeolithic? To what extent and at what scale did spatial and temporal diversity in vegetation occur? How was the animal community composed in terms of species representation, population structure and geographical occurrence in space and time?

At the Pleistocene/Holocene transition, all parts of northwest Europe, including Scandinavia, would eventually be colonised by hunter-gatherers. Rapid sea-level rise invoked dramatic changes in the palaeogeography, while increasing temperatures, combined with altering precipitation patterns, led to rapidly changing plant and animal communities. Based on the Scandinavian evidence, it seems plausible that the early Holocene colonisation of the northern latitudes was strongly related to coastal exploitation (Bjerck, 2009). Indeed, coastal adaptations have been considered crucial to the spread of humans, and the emergence of complex societies (e.g. Bailey & Milner, 2002; Bailey, 2004). Furthermore, the rapid submergence of Coles' (1998) Doggerland led to the loss of territory, a process which is believed to have triggered increasing competition among Mesolithic hunter-gatherer groups (Waddington, 2007a; Gaffney et al., 2009; Momber, 2011).

The concept of territory loss in the North Sea basin is one that sets the Later Mesolithic people apart from the Late Palaeolithic cultures of the relatively warm Allerød period. At this time, the low sea levels following the LGM allowed people to occupy an extensive land mass that became habitable on the northwest European continental shelf. The subsequent depopulation of the region during the Younger Dryas triggered by the advance of arctic conditions would have seen the retreat of the flora and fauna. The process allowed the technologies to move where they could continue to be used, as discussed above.

The depletions caused by the climatic changes left a land that was denuded and ready for population growth when the conditions ameliorated. The Mesolithic hunter-gatherers who dominated the more promising environment at the onset of the Holocene were the Maglemosian. Their presence has been recorded on both sides of the North Sea basin from Scotland to Poland (Clark, 1936; Bang-Anderson, 2003; David 2009). Like the Late Palaeolithic that preceded them, the first Maglemose people were pioneering, but they rapidly colonised the land in its full extent (Leakey, 1951; Rankine, 1952; Clark, 1954; Reynier 2000; Conneller, 2009a).

The introduction of Later Mesolithic technologies within the next few thousand years occurred at a time when broad-leaf woodlands were advancing from the south and the natural landscape was changing considerably. Sea levels had also risen markedly and in doing so would have overwhelmed territories that were previously available for exploitation. This is also a time that saw an increase in the divergence of cultural technologies and the development of more regional identities within the European arena (Clark, 1936; Jacobi, 1981; Gumiński

& Michniewicz, 2003; Bell, 2007; Suddaby, 2007; Warren, 2007; Conneller, 2009b; Lübke, 2009; Schulting, 2009; Wickham-Jones, 2009; Momber, 2011). Europe included the North Sea basin, which was rich in favourable fluvial environments. Being that the evidence recovered from the seabed (as outlined in this paper) suggests the area was occupied, the reduction in available land is very significant. This was compounded by the potential for increased attraction as it was potentially becoming more productive with the increased growth of protein-rich estuaries extending from the north and south. Such environmental changes have been recorded in the Baltic and the Solent, where the archaeology suggests technological and social change (Fischer, 1997, 2004; Pedersen, 1997; Grøn, 2003; Åstveit, 2009; Momber, 2011).

The positioning of the North Sea as an important part of the Mesolithic world goes as far back as the early 20th century (Reid, 1913; Clark, 1936). The whole idea was based on assertions about the presence of Maglemose hunter-gatherers in Scandinavia and Britain, but, significantly, also on the presence of tree remains that were frequently 'caught' in fishing nets or were observed along the British coasts at low tide. Clearly, these indicated the existence of submerged forests, at the time referred to as 'Noah's Woods' by many locals (Gaffney et al., 2009). Submerged forests were not only known from the British coast, but also from the Baltic (Pedersen et al., 1997) and the Netherlands (Wiggers, 1955). Occasional finds of bone and antler implements of undisputable Mesolithic age, and trawled up from the sea floor, provided definite proof for human presence (Clark, 1936; Louwe Kooijmans, 1971). However, the perspective taken was very much a terrestrial one, where the North Sea formed a natural land bridge, connecting Britain with the European continent. Coles' (1998) paper took a radically different turn, positioning Doggerland as one of the core areas of Mesolithic northwest Europe (Fig. 1).

In view of the palaeogeographical evolution of the early Holocene northwest European landscape (Ward et al., 2006; Cohen et al., 2014), it is apparent that much of the early Mesolithic world is now under water. This raises questions about the representativeness of the archaeological record as we know it from terrestrial northwest Europe. If coasts were highly attractive to hunter-gatherers, what did settlements along the coasts look like? Were there higher population densities, and was there continuous, year-round presence of people? How were coastal zones related to the inland? To what extent did the exploitation of coastal zones change with the shifting of coastlines due to sea-level rise? After all, sea-level rise does not only imply changes in the shoreline, but also in the characteristics of marine coastal dynamics (Beets & van der Spek, 2000) as well as coastal ecology.

It is also within this framework of questions that the definition of a coastal site as opposed to an inland site should be considered. The work at Bouldnor Cliff in the UK (Fig. 2a) has revealed a site with the potential for year-round occupation and indications of sedentism (Momber et al., 2011). At the time

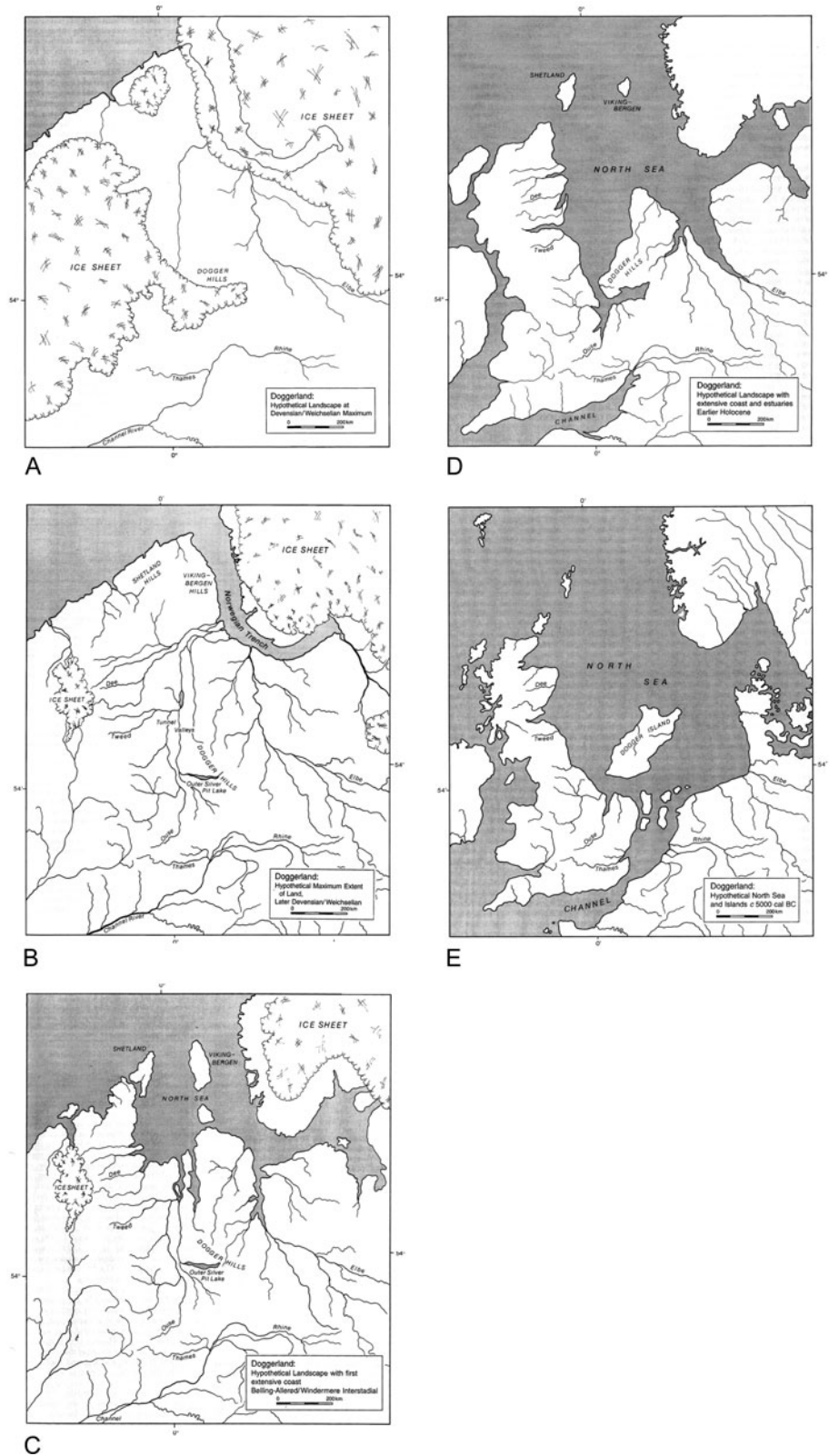


Fig. 1. Time series of palaeogeographic reconstructions of the North Sea basin as published by Coles (1998).

of the human recorded occupation at the site, which now lies 11–12 m below British Ordnance Datum, sea levels were lower still. The area was within a lacustrine basin just 10–12 km from the coastline and provided a wide diversity of resources. It could be argued that it benefited from being both a coastal

and inland location as it was a site that was inland but yet within the coastal zone. However, by 8000 cal BP it became the coastline as the sea level rose. When this happened people adjusted and occupation continued. This was a process that all the people of southern England had to respond to if they were

to continue exploiting the same established hunting and gathering territories.

None of the answers to these questions will be straightforward as sea-level rise meant the environment was changing continuously and the effects would have varied across a geographically diverse area. We need to look at the sub-regional scale to ask, did the loss of territories have a negative or positive influence on evolving social interactions? Did the extension of coastlines induce greater technological adaptations in each case? If so can we see continuity of traditions after

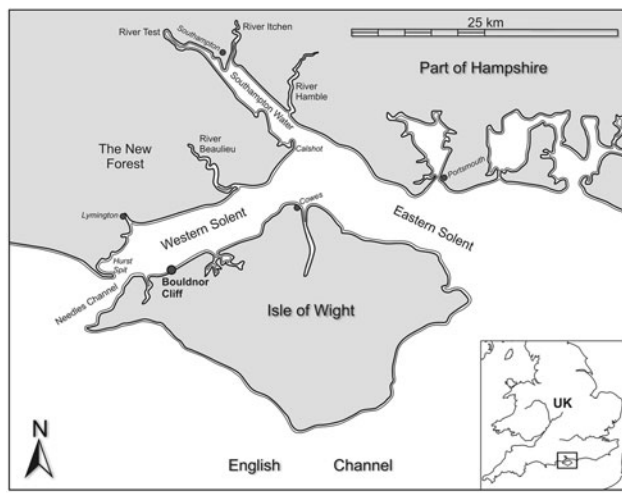
lands were drowned? Research into sites from Great Britain demonstrates that there was a divergence in cultural activity from mainland Europe during and particularly after severance (Woodman, 2003; Bell, 2007; Waddington, 2007b; Conneller, 2009a; Wickham-Jones, 2009). It has been postulated that technological developments could have been stifled once Britain had become an island (Momber, 2011); if so what impact did the transgression have on the smaller islands that were formed by the rise in sea level? Some of these may have lasted for a thousand years and more before finally being extinguished by the sea.

Apart from the effects of environmental change on the presence and distribution of crucial resources to hunter-gatherer communities, the gradual loss of land will undoubtedly have affected people in a mental way (e.g. Leary, 2009), as did the occurrence of a tsunami, triggered by the Storrega land slide off the Norwegian coast at ~8200/8300 cal BP (Weninger et al., 2008) or the sea-level jump resulting from the Lake Agassiz drainage (Hijma & Cohen, 2010). However, the impact of land loss and particular events such as a tsunami on people will have been very different, depending on the specific and variable conditions along the coasts. To draw inferences from the archaeological record with regard to such a topic, detailed insight in the timing and extent of these processes and events is needed with explicit attention to (sub-) regional variability. To what extent was the environment affected? Did this have an effect of technological developments between different locales? How long were highs such as Dogger Bank and Brown Bank accessible? Do polished flint axe blades from the North Sea indicate the presence of islands in the Neolithic, or are they related to perceptions of this seascape in reference to the land that once was? Indeed, this invokes further questions with regard to the sea-faring abilities of the Mesolithic and Neolithic people (Garrow & Sturt, 2011; van de Noort, 2011).

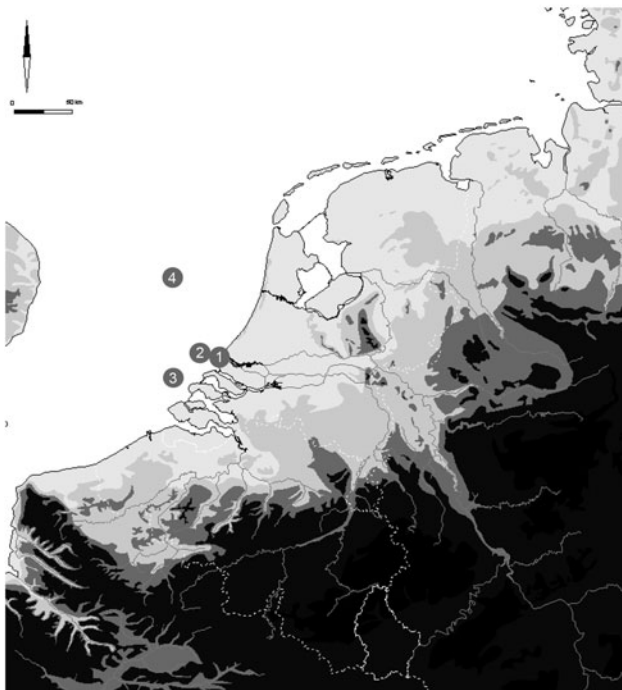
Archaeological evidence and taphonomy

So, what archaeological evidence do we have then to underpin the theoretical importance of the North Sea as outlined above? Admittedly, this is not very much as yet. In some cases we are dealing with direct evidence, that is, artefacts, bones with butchery marks and human remains. In other cases, indirect evidence permits some first inferences to be made with regard to some of the many questions passed in review. We will briefly discuss the evidence below.

Ever since the discovery of the 'Colinda point' on the Leman and Ower Banks in 1931, prehistoric artefacts have been brought up frequently. The majority of these finds originate from the Brown Bank and Eurogeul area, off the Dutch coast (Fig. 2b). An overview was published by Louwe Kooijmans (1971), who discussed the finds in relation to sea-level rise, and, at the time, coarse-grained models of palaeogeographic developments. Owing to innovations in the fishing industry,



A



B

Fig. 2. a. Geographic location of Bouldnor Cliff in the Solent, UK. b. Geographic location of archaeological sites and find zones off the Dutch coast. 1, Maasvlakte-Rotterdam harbour (Europoort); 2, Eurogeul; 3, Middeldiep; 4, Brown Bank De Stekels.

and the use of beam-trawling in particular, there was a steady rise in the number of finds from the mid-1980s (Verhart, 1995, 2004; Glimmerveen et al., 2004). Close cooperation between Dutch fishermen and palaeontologists, who were keen to collect the many thousands of fossil bone remains that were caught in the fishing nets, was crucial. More direct research was initiated in Britain, where conditions for underwater surveys are somewhat better. One of the more exciting discoveries was that made at Bouldnor Cliff in the Solent (see above), where *in situ* remains of a Mesolithic settlement have been exposed (Momber, 2011). However, the total number and quality of observations from the North Sea lags far behind those from the Baltic (Fischer, 1995, 2004; Jöns et al., 2007) because of differences in accessibility and taphonomy.

The record as we presently know it shows some striking gaps. Several areas in the North Sea have produced Middle Palaeolithic artefacts (Glimmerveen et al., 2004; Verhart, 2004; Tizzard et al., 2011), and even a fragment of a Neanderthal skull (Hublin et al., 2009) in addition to uncountable numbers of Pleistocene mammal remains (Mol et al., 2006). Next comes a reasonable number of finds, securely anchored in the Mesolithic (Preboreal-Boreal) by means of radiocarbon dates (Glimmerveen et al., 2004). However, finds that can securely be dated in the Late Palaeolithic are absent, except for the Colinda harpoon, which has been dated to $11,740 \pm 150$ BP (Housley, 1991). The Viking Bergen flint artefact found in a vibrocore off the Norwegian coast (Long et al., 1986) could be of Upper Palaeolithic age, but as the specimen originates from washed sands, nothing can corroborate this; even a Middle Palaeolithic date cannot be excluded. In fact, this absence of evidence for Late Paleolithic activity is as surprising as the indication for Neolithic activity, which is evident from a number of Neolithic axe blades from Brown Bank (Maarleveld, 1984; Glimmerveen, 2007) and Dogger Bank (van de Noort, 2011).

As Roebroeks (2014) points out, the North Sea basin may have been the limit of Upper Palaeolithic hunter-gatherer presence. Notwithstanding the taphonomical bias that affects the integrity of the archaeological record, the number of Aurignacian and Gravettian sites in the surroundings of the North Sea is extremely low indeed. Hence, it is not surprising that this phase is not represented in the North Sea record; it is a matter of statistical probability that such material would be found if present at all. Clearly, this is not the case for the preceding late Middle Palaeolithic, for which there is evidence in the North Sea. Notably, the Neanderthal frontal bone discovered off the Dutch coast (Middeldiep) seems to fit best the morphological features of late Neanderthals, to which several of the northwest European cave specimens (Spy, Neanderthal) belong. Indeed,

the North Sea basin with its surrounding highs may have been one of the last Neanderthal refuges (Roebroeks, 2014). Neanderthals were present in this region during the early Weichselian/Devensian, and at least as far north as the northern Netherlands.

Why then do we hardly have any solid evidence for human presence in the North Sea area after the LGM, before the Mesolithic? After all, as the terrestrial evidence in both Britain and the continent shows, hunter-gatherers were definitely occupying the territory. In fact, as of $\sim 13,000$ BP there is more or less continuous occupation that was only interrupted (locally?) during short-lasting Dryas cold spells. It is important to note that the palaeontological evidence equally shows a lack of post-LGM material that can securely be dated in the Late Glacial (Fig. 3). So far, only two bones (the aurochs *Bos primigenius* and a goat-like animal) are dated between 20,000 and 10,000–11,000 BP. Typically, a series of radiocarbon analyses on reindeer remains delivered only pre-LGM dates, while reindeer bone/antler from the North Sea shows no convincing indications of human activity (Glimmerveen et al., 2006).² The contrasting evidence, then, is all the more surprising.

Of course, one important question that has to be considered is to what extent erosion of Late Glacial sediments may have contributed to this gap in the archaeological record. The dynamics related to sea-level rise and the transformation of the area into a full marine environment will certainly have affected the preservation of earlier deposits. Reference to the geological records shows that the effects would have occurred locally rather than on a 'landscape-wide' scale (Cohen et al., 2014). The impact of the transgression would depend on the topography at any given location. Where land is exposed, it will suffer attrition from the sea and erode, but where sites are protected from the force of the rising water, they can be protected by sediments.

Generally speaking, sedimentation will occur in sheltered, deltaic estuarine environments. Fluvial channels and coastal lakes would act as catchments for particulate matter. These sediments would drop from the water column when rivers slow as they meet the sea. In addition, as the sea levels increase pressure on the coast, water tables are forced up creating stagnant lagoons on land that was previously dry. Where fine sediments drop to form silt, terrestrial material can be encapsulated and preserved in an anaerobic environment. If undisturbed it can survive for many thousands of years. With time, as the sea continues to rise, sedimentation would continue to extend steadily inland, overwhelming coastal fringes, river banks and the shores of lakes. All such fluvial and marine site types are known to be attractive for human occupation.

² Earlier claims of worked reindeer antler and some bones attributed to *Rangifer tarandus* with cutmarks (van Noort & Wouters 1987) are highly disputable. The cutmarks shown can very well have a natural origin (e.g. gnawing), whereas the taxonomic attribution is not confirmed. Some decorated reindeer antlers trawled up somewhat south of Dogger Bank have been reported and were attributed to the Ahrensburgian (van Noort et al., 2002). At this stage, it remains unverified whether this claim is justified or not.

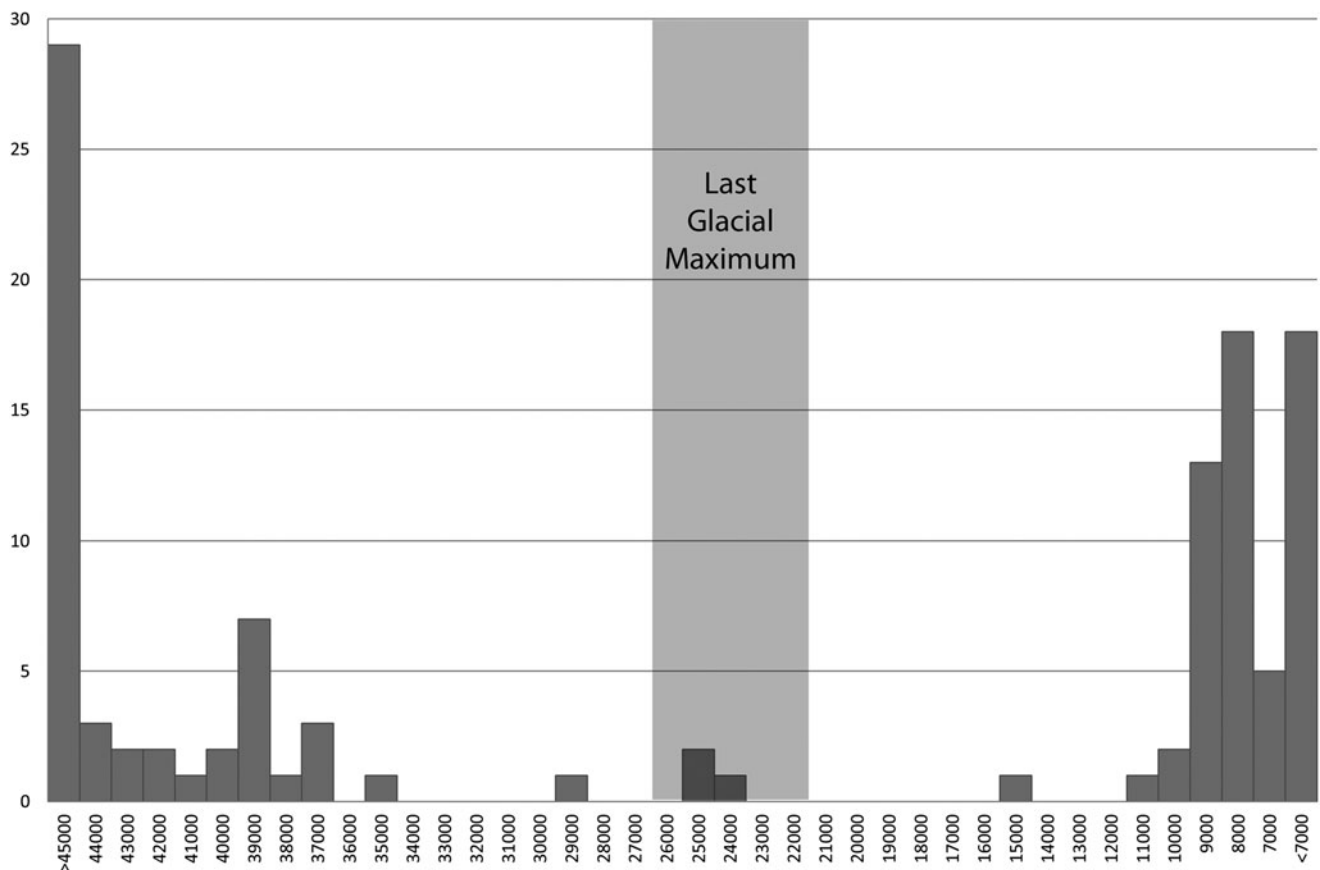


Fig. 3. Number of radiocarbon dates (in 1000 year lags) on bone remains from the North Sea (data from Glimmerveen et al., 2004, 2006; Mol et al., 2006). x-axis, radiocarbon age; y-axis, frequency of radiocarbon dates.

A consequence of these processes will be the filling of palaeo-ri- ver channels, lakes and coastal plains with deep sedimentary deposits. Recent studies have identified a multitude of such palaeofeatures (Gaffney et al., 2007). Where archaeological material is covered by these deposits they would be buried and preserved within the anaerobic silts beneath the seabed. Once the palaeolandscape becomes covered by open water they can become masked by mobile marine sediments or sand banks. However, the seabed is continually transformed and marine hydrodynamic regimes can modify erosive currents to expose areas of seabed that have remained undisturbed since their deposition. These exposures would invariably represent only a small part of any site at a given time. Notwithstanding taphonomic variations, this suggests there could be further Mesolithic material preserved beneath the seabed in associated archaeological horizons (Fig. 4). Unfortunately, once prehistoric material becomes exposed on the seafloor, organic artefacts will quickly degrade, and fine flakes and flints will be dispersed. The chance for their discovery would have to occur within a very narrow temporal and spatial window, therefore very few sites have been found exposed on the sea floor.

When considering finds recovered from the surface of the seafloor the only way to discover any temporal patterning in the palaeontological record is by means of radiocarbon dating,

as there is no possibility to date bone remains chronologically on the basis of degrees of fossilisation other than by approximation (Mol and Glimmerveen, pers. comm.). Another factor may be an incidental bias owing to the geographical occurrence of remains from various periods and the exposure of materials on the seabed, and the subsequent change of discovery in the context of fishing and aggregate extraction.

In view of the above, it goes without saying that for the time being we can only reasonably draw some inferences with regard to the occupation of the North Sea during the early part of the Holocene. The most instructive find occurrences currently known are De Stekels near Brown Bank and Maasvlakte-Europoort off the Dutch coast, and Bouldnor Cliff in the Solent, Britain (Fig. 2).

De Stekels represents a zone southwest of Brown Bank, where more than 100 artefacts and human remains have been trawled up over the past two decades (Glimmerveen et al., 2004). Most artefacts are of bone and antler, and comprise tools such as perforated and socketed adzes, but some stone implements (mace heads) have been collected as well. The human remains comprise two lower jaws and several cranial fragments. Among the bone and antler is one zigzag-decorated adze, while in another case part of the wooden shaft has been preserved. This points to generally good preservation conditions and limited transport of objects since the exposure at the seafloor.

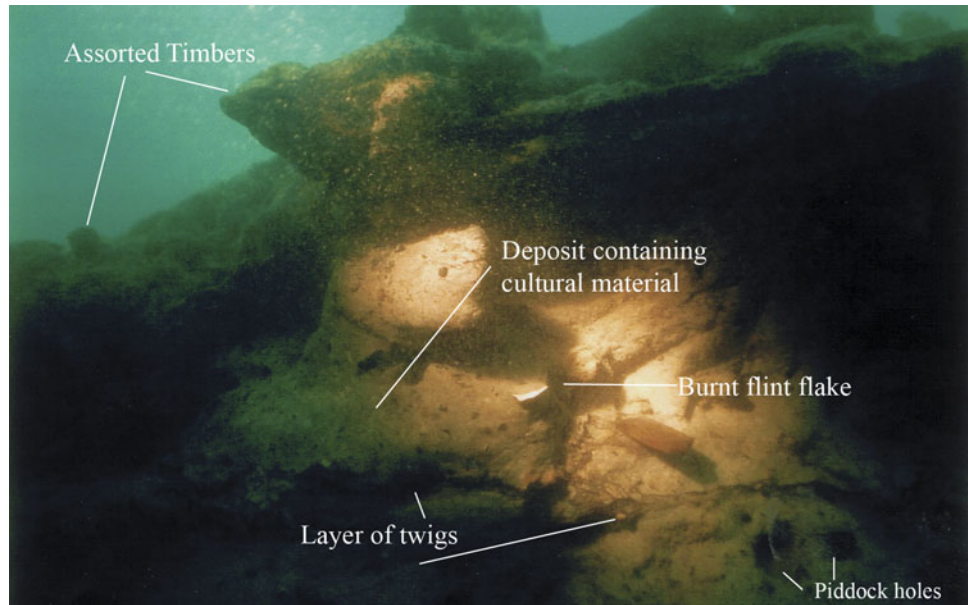


Fig. 4. Bouldnor Cliff: seam of in situ archaeological remains eroding out of a Mesolithic horizon 11 m below UK, Ordnance Datum. Organic artefacts remained well preserved for over 8000 years beneath alluvial deposits that filled the palaeochannel. Changes to the modern waterway are now causing exposure and loss of the submerged landscape.

The human remains may point to the presence of Mesolithic burials, and possibly a cemetery. If this indeed is the case, De Stekels hosts one of the earliest Mesolithic cemeteries known to date in northwest Europe.

The second occurrence is the well-known site of Maasvlakte-Europoort (Rotterdam, the Netherlands). Over 500 bone and antler implements, mainly barbed points, were collected in the 1970 and 1980s (Louwe Kooijmans, 1971; Verhart, 1988). The exceptionally high number of bone points from Maasvlakte-Europoort is unique in northwest Europe, but has parallels at Star Carr, Britain, and Hohen Viecheln, Germany. As yet, not much is known about the original stratigraphic position of the Maasvlakte artefacts, but recently conducted research in the extension zone of Rotterdam harbour demonstrates the presence of an intact Late Glacial to Early Holocene sequence (Vos et al., 2010). Important new insights are expected to come from a large aeolian river dune located in the Yangtze harbour basin. Targeted research based on seismic and core data (Fig. 5) demonstrated the presence of

a Mesolithic site on the flank of this dune, and several thousands of flint and bone fragments have been recovered during an excavation conducted in 2011. Despite the fact that there is only limited control over the exact stratigraphical (vertical and horizontal) position of the finds, the site is of major importance as it demonstrates the presence of early Mesolithic settlement locations next to the rich harpoon assemblage. It will allow investigation of the behavioural context of the points from a new perspective.

Finally, in the case of Bouldnor Cliff, in the Solent, underwater excavation works have documented parts of an eroding Mesolithic settlement showing signs of industrial activity (Mombert et al., 2011). Apart from worked flint, hearths, spalls of wood, carbonised wood and stockpiles of heated flints, over 20 pieces of interconnected worked wood have been found, many with evidence of working. Furthermore, the unusual find of fragments of string made out of vegetable fibres (Fig. 6) has been reported and a large piece of tangentially split timber has been unearthed

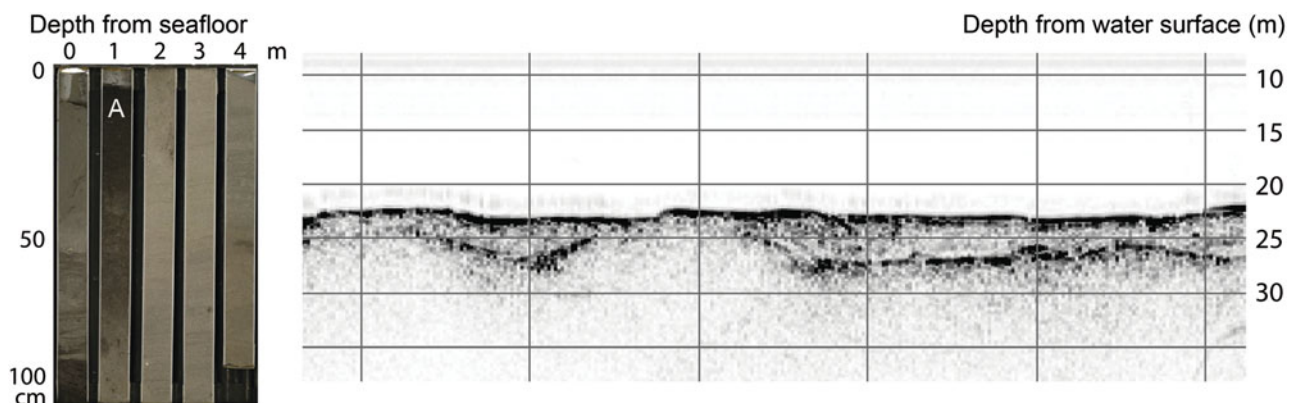


Fig. 5. Maasvlakte-Rotterdam harbour. Left, high-resolution vibrocore showing an undisturbed archaeological layer (A) in the top of aeolian riverdune sand; right, seismic profile showing the river dune in the middle (copyright Deltares, Utrecht).

(Taylor in Momber et al., 2011). The method of splitting timber in this way is a technology that does not appear in the British archaeological record for another 2000 years. We have yet to determine why this is the case. Was it that evidence of similar technologies have not survived on dry land or were certain skills lost following the drowning of occupation sites and separation from mainland Europe? The Solent was an area with raw materials where fresh water and estuarine resources were easily accessible, enabling year-round occupation. Did these skills evolve here in isolation? Bouldnor Cliff was occupied prior to the formation of the North Sea. Were there cultures existing at the same time with similar technical skills distributed around the estuaries and lakes that still remained in the North Sea Basin? If so, and if sites could be found, can they provide evidence for the genesis of some of the technological idiosyncrasies that now appear in the archaeological record on land?

A final question that the work at Bouldnor Cliff is helping to address is the process that enabled the sites to survive. The preserved landscape is covered in 7–8 m of estuarine sediment. It became exposed due to a change in the marine geomorphology that has stripped a channel through the deposit. It became exposed due to a change in the marine geomorphology that has stripped a channel through the deposit, which sits in section at the base of a 7-m thick alluvial deposit (Fig. 7). Which sits in section at the base of a 7-m thick alluvial deposit (Fig. 7). If the channel had not cut through the deposit, it would have remained buried deep below the seabed. The investigations by



A



B

Fig. 6. a. Bouldnor Cliff: a 10-cm long piece of Mesolithic twisted fibre string. b. Bouldnor Cliff: detail of the string.

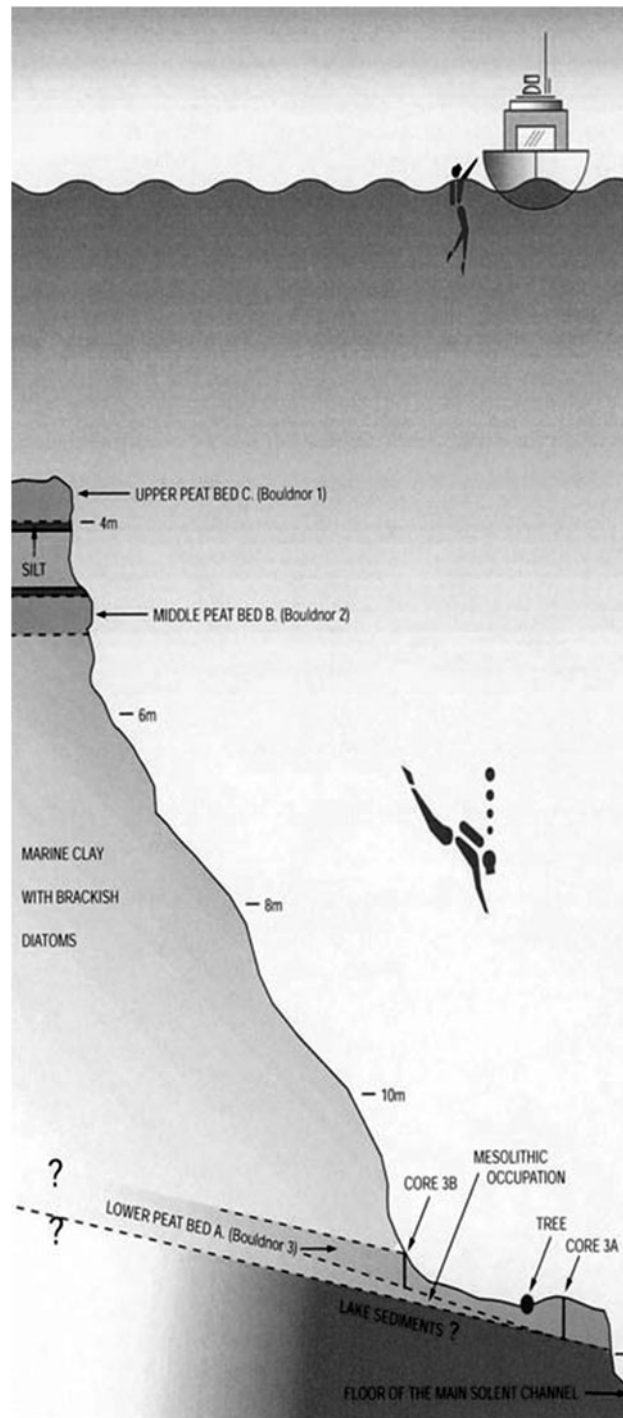


Fig. 7. Bouldnor Cliff: schematic representation of the stratigraphy and exposure of the archaeological layer. The alluvial deposits that protected the palaeo-landscape are now being eroded to form a 7-m high section that is steadily receding.

the Vista team of the University of Birmingham (Gaffney et al., 2007) have located many similar sub-bottom geomorphological characteristics and sediment sinks in the North Sea. Many of these are still filled with sediment, with a high potential for the preservation of palaeolandscapes. The recovery of Mesolithic artefacts by

Table 1. General preservation rating for different landform elements in the southern North Sea, derived from a combination of (1) the probability of occurrence of archaeological and palaeoenvironmental remains and (2) the potential risk to these from natural and anthropogenic processes (from Ward & Larcombe 2008, p. 67).

Environment	Primary deposit	Preservation rating	Secondary deposit	Preservation rating
Glacial				
Glaciofluvial	–	–	Human occupation along channel margins Artefacts incorporated into glaciofluvial and debris-flow deposits	Low
Glaciolacustrine	–	–	Human occupation of lake margins (glacial) and abandoned beaches (post-glacial)	High
Tunnel valley	–	–	Abandoned artefacts within sand and gravel deposits	Medium
Lake				
Basin	Abandoned artefacts incorporated into muds (possible lake dwellings)	Medium-high	–	–
Shoreline	Human occupation of lake margins Gravelly sediments	Medium-high	–	–
Fenland				
Fenland	Human occupation of fenland, preservation in silty-mud/peat Possible indicator of transgression/regression	High	–	–
Riverine				
Channel/channel belt	–	–	Sand and gravel associated with bars channel lag and channel fill may preserve material particularly in aggradational system	Low
Overbank (including crevasse splay and abandoned channel)	Sand, silt deposits provide potential for human occupation and preservation	Medium	Abandoned channels with low-energy sediments ideal for preservation Potential for re-erosion in meandering system, artefacts reworked downstream	Medium-high
Alluvial plain	Sand, gravel	Low	–	–
Floodplain	Human occupation of floodplain with deposits buried in fine sands associated with flood deposits and/or peat deposits in shallow depressions or infilled palaeochannels	High	–	–
Terrace	Many examples of terraces as focus for settlement and preservation of archaeological sites	Medium	–	–
Estuarine				
Intertidal sand (and shallow subtidal sand)	–	–	Abandoned artefacts only	Low
Intertidal mud (shallow shallow subtidal sand)	Abandoned artefacts incorporated into silty muds/peat	Medium	–	–

Table 1 continued.

Environment	Primary deposit	Preservation rating	Secondary deposit	Preservation rating
Salt-marsh	Microfossils useful for defining tidal datum levels Potential for temporary occupation sites	Medium	–	–
Lagoon/barrier	Sheltered environments with low-energy silty-sand/muds and marginal peat	High	–	–
Open coast				
Sandy beach	Significant reworking	Low	–	–
Dune ridge	Potential for indicating transgression/regression phases, and preservation of underlying deposits	Medium-high	–	–
Tidal channel	Significant reworking	Low	–	–
Tidal sand bar	Significant reworking	Low	–	–

The ratings do not reflect the actual quality or significance of any archaeological or palaeoenvironmental remains, which remain unknown. The list of landform elements and possible deposits is not exhaustive.

trawlers demonstrates that similar terrestrial deposits are becoming exposed. The work at Bouldnor Cliff has permitted, for the first time in British archaeology, the documentation of a well-preserved, yet quickly degrading Mesolithic site under water and is highlighting the possibility of comparable sites within the southern North Sea.

Survival and research potential

The good preservation of Mesolithic remains at the occurrences referred to above infers a high research potential. However, it should be born in mind that we are just getting a first glimpse of what the North Sea may be hiding; we are largely unaware of how much is still out there. Above we have addressed some problems with regard to the surprising absence of evidence of Upper Palaeolithic finds in particular. Clearly, the question of survival of sites, or for that matter entire landscapes, has to be considered for the period we focus on in this paper. How fair is it to expect all phases of Late Palaeolithic and Mesolithic settlement, as documented in the countries bordering the North Sea, to be equally present below the seafloor? Put differently, what is the research potential of the North Sea compared to terrestrial northwest Europe?

A first step to get a better understanding of this problem was taken by Ward & Larcombe (2008). In their study they combined geomorphological features with an estimate of site survival, in order to come to a preservation rating in the southern North Sea area (Table I). However simple their approach may appear, it provides a clear-cut framework that can be elaborated in far more detail. An important matter that has to be dealt with is the spatial and temporal scale at which we would like to assess the research potential. Clearly, as Cohen et al. (2014) show, and

is also recognised by Ward & Larcombe (2008), the specific nature and sequence of geogenetic developments can be very complex and variable owing to (sub) regional and local differences. Relative sea-level rise, for example, is far from uniform, even along the Dutch coastline (Kiden et al., 2002). Differences in timing, combined with coastal geometry and sedimentation rates, can produce major differences in the palaeogeographical evolution, even over relatively short distances. The North Sea basin is a highly complex environment that cannot be summarised in terms of some simple models.

The complex nature of sedimentation-erosion dynamics becomes all the more apparent in the spectacular results obtained from analysis of 3D seismic data by Gaffney and Fitch (Gaffney et al., 2007; van Heteren et al., 2014). In contrast to what was long believed, the Dogger Bank area has now been shown to contain a variety of geomorphological structures, dating from the periods before submergence. However, within the very same area, expectations with regard to preservation potential are not uniform (Gaffney et al., 2007, p. 115). In fact, higher degrees of preservation potential are strongly related to relatively small-scale landscape features, such as former fluvial channels and lacustrine features (e.g. in the case of Bouldnor Cliff). For that matter, it is important to note that technological developments in the field of seismic surveying and digital data analysis are facilitating the collection of increasingly detailed data. Examples are the possible detection of a drowned forest on the eastern end of Dogger Bank (Hansen, 1981) and the detection of a Mid Holocene tidal channel network in shallow water, off the Dutch coast (Rieu et al., 2005). The survival of Late Glacial and earlier Holocene landforms is, of course, vital to determine the significance of the North Sea for the

archaeology of post-LGM hunter-gatherers. Notwithstanding the fact that there is still much to gain in the construction of spatial and temporal frameworks, as well as the geogenetical validation and temporal anchoring of mapped landscape features such as at Dogger Bank, the recent developments are overwhelmingly positive.

However, the significance of the North Sea is not only a matter of preservation conditions. From our outline of the post-LGM settlement history of northwest Europe until the final submergence of North Sea islands, it should be apparent that the North Sea not only fills a crucial geographical gap, but was also the scene for major changes in the relationships between people and the land. From this perspective, even coarse-grained data, such as those of dredged-up and trawled-up finds, can be extremely informative. Through a combination of high-level taphonomic studies and intrinsic information from the finds themselves, patterns may be revealed that are meaningful for the understanding of settlement histories in a wider setting. Hence, the degree to which we can frame the place and time of materials, be it artefacts or whatever else that is considered to be of importance, defines a baseline for the underpinning of the North Sea's significance. Through cooperation between the research community and industry, protocols can be agreed upon to stimulate the recording of find coordinates and sedimentary context. Radiocarbon dating can help in chronologically positioning individual objects, although we must remain cautious with respect to the interpretation of results (cf. Roebroeks, 2014).

Conclusions

The archaeological record following the LGM indicates that the North Sea was potentially the confluence of Late Palaeolithic hunter-gatherer populations. This was an expansive lowland area that would have been the crossroads between the highlands of Britain and Continental Europe landmass. Archaeological material from the period therefore has the potential to enhance our understanding of the Late Palaeolithic adaptive strategies practiced by the evolving cultures that diffused across the seamless landscape. Following the Younger Dryas, the changing relationship between land, sea and vegetation dictated the need for adaptation by the growing Mesolithic population. In the North Sea basin this culminated with the separation of Britain from mainland Europe by the rising sea. The forced dispersal of human population brought on by the ingress of the sea ultimately led to relative isolation and variations in cultural activity.

The formation of the North Sea has presented a dichotomy that challenges our ability to answer many of the research questions posed in this paper. The recovery of archaeological data from the seabed would, however, help inform considered responses. The discovery of artefacts around the Brown Bank has confirmed the existence of exposed archaeological material

that is lying near the surface of the seafloor in a location where it can be easily recovered. In addition, our growing understanding of the buried palaeolandscape beneath the post-transgression morphology of the North Sea is revealing areas of rich potential for human occupation. The potential for survival of archaeological material is being further realised following the rich concentration of artefacts found at Bouldnor Cliff and as a consequence of the finds uncovered during the Maasvlakte-Europoort development. Both assemblages were recovered from beneath metres of sediment where they had been exquisitely preserved. These sites currently provide unique opportunities to access complex (archaeological) landscapes that witnessed different social functions, with relative ease. An understanding of the interplay between human activities and these landscapes could be used as a proxy when interpreting similar sites that are identified as a consequence of development or by geophysical prospection. A way forward should therefore include the continued archaeological investigation of these sites as this would help to quantify the research potential in the Channel and North Sea, assist in the identification of new sites and aid our understanding of the significant deposits that remain.

As we better understand the geomorphological processes that reshaped the landscape during the Holocene transgression, where valleys would have been filled with sediment while exposed sites were lost to erosion, it is surprising that we have found anything at all. Consequently, we are forced to conclude that rich seams of prehistoric landscape remain within the southern North Sea that have the potential to address a range of research questions, many of which cannot be resolved by interrogation of terrestrial deposits.

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