NORTHSEALAND.

A STUDY OF THE EFFECTS, PERCEPTIONS OF AND RESPONSES TO MESOLITHIC SEA-LEVEL RISE IN THE SOUTHERN NORTH SEA AND CHANNEL/MANCHE

A thesis submitted to The University of Manchester for the degree of Doctor of Philosophy in the Faculty of Humanities.

2013

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Final word count: 75,693

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Abstract

This study identifies and critically assesses the social and physical consequences of, and possible responses to, sea-level rise and loss of land in the area that is now covered by the southern North Sea and English Channel/La Manche during the Mesolithic period. It suggests that Mesolithic studies still, despite debate on the matter, frame hunter fisher gatherers in economic terms. In this way, nature is seen as a separate entity to culture, the changing environment, therefore, becomes an external force against which people struggle. However, as an alternative, this thesis advocates an understanding of Mesolithic hunter fisher gatherers as an integral part of their changing world, suggesting that they would have had a fundamental awareness of these changes through a sensorial engagement, and acted accordingly. That said, it also suggests that, while not all people living in the area were equally affected by sea-level rise, the associated loss of land could have profoundly impacted people's sense of place and being.

It also highlights that, although sea-level rise and climate change occurred globally and on a millennial-scale, it unfolded and was experienced at a local and generational level. It therefore makes a case that to understand the human experience of early Holocene sea-level rise, it must be studied at the local-scale. This provides us with a better understanding of the effects of sea-level rise – a sense of the experience of it, rather than simply recording it as an abstract concept. Further, the local scale can identify problems that are not necessarily obvious from the larger scale.

In this way, this thesis captures some of the nuances of environmental change that are frequently missing from the archaeological literature, and highlights the intense relationship between humans and their environment, providing a fresh approach to Mesolithic environment relations and a richer and more complex story of the effects of early Holocene sea-level rise.

Declaration

I declare that no portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Parts of Chapters 5 and 6 were published in 'Leary, J. 2009. Perceptions of and responses to the Holocene flooding of the North Sea lowlands. *Oxford Journal of Archaeology* 28(3), 227–37', and 'Leary, J. 2011. Experiencing change on the prehistoric shores of Northsealand; an anthropological perspective on early Holocene sea-level rise. In J. Benjamin, C. Bonsall, C. Pickard, and A. Fischer (ed.) *Submerged Prehistory*, 75–84. Oxford: Oxbow Books'. Some of the themes developed in Chapters 2 and 5 have been submitted as 'Leary, J. Forthcoming. Place, placelessness and sea-level rise in the Mesolithic. In *Meso 2010. The eighth international conference on the Mesolithic in Europe*. Oxford: Oxbow Books'.

Elements of the thesis (particularly Chapters 5 and 6) were presented at the '10th Northern Hunter Gatherer Discussion Forum' at the University of Birmingham in 2009, and in the same year at the '15th EAA annual conference' in Riva del Garda, Italy. The research in general was also presented at 'Meso 2010' in Santander, Spain – the 8th five-yearly international conference on the Mesolithic in Europe, and the section on local-scale analysis were presented at the 32nd Theoretical Archaeology Group annual conference at the University of Bristol in 2010.

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Acknowledgements

I would like to thank my supervisor, Chantal Conneller, for support, patience and encouragement throughout my doctoral research. I am also very grateful to my subsidiary supervisors, Colin Richards and Jamie Woodward. Together, they took the time to comment on this work, provide direction, and generously shared thoughts and ideas. I am indebted to The University of Manchester for a Studentship award that paid for my university fees from the second year onwards, and I am truly grateful to English Heritage, particularly Sarah May, Michael Russell and Brian Kerr, for allowing me the substantial amount of time required to do this work. English Heritage also provided some funding in the initial year. I would also like to thank Vince Griffin from the EH graphics office for assistance producing Figs. 1.5, 1.9–1.13, and 4.1, and Elaine Jamieson for assistance with Figs. 5.1, 5.3 and 5.6.

I am very grateful to Peter Murphy, Ian Oxley, Zoë Hazell and Clive Waddington for discussions on their research at various stages. Particularly to Peter for allowing me use of his photograph reproduced as Fig. 5.2, and similarly Clive for sending Fig. 6.2. I would also like to thank Andrew David, Lucy Farr, Ben Gearey, and Hannah Cobb for comments and thoughts on the work, and for making unpublished material available. Special thanks must go to Dave Field for comments, ideas, encouragement and for generally being a constant source of archaeological inspiration.

This thesis was written in memory of three special people from three generations who inspired and encouraged in different ways: my grandmother, Gwyneth Rowley, my mother, Jenny, and my brother, Piers –

thank you! A thank you too, to dad, Justin, Chris, Becky and Lawrence for discussions and votes of confidence.

Finally, I would like to thank my wife, Ellie, for never-ending support during the last six years, and our two young daughters, Dora and Aggie, for reminding me of the important things in life. Embarking on part-time doctoral research alongside a full-time job and a young family is a selfish act, so thank you for allowing me the time and space to get on with it. I hope all those long hours and lost weekends pay off. By way of some small token, I dedicate this thesis, with love and pride, to all three of you.

Preface

Sitting in a hotel room in India in 2005, or maybe 2006, something caught my eye on the television. I do not remember the detail or even the programme (perhaps it was BBC World news), but it was about modern sea-level rise and the effect on islanders in the Pacific Ocean. A man, possibly from Tuvalu, was standing in the sea up to his knees, his trousers rolled up to just above the water-line, and he was pointing at the ground beneath the waves and speaking. The subtitles read: “this is my ancestral land. My father and my grandfather lived here, but there is nothing of it left for me.” That image and his words have stayed with me. A light went on in my head and it made me wonder about sea-level rise in the past: not the recording of it, but the human experience – what it felt like, what affect it had. I have thought about it a lot since and this thesis is a culmination of those thoughts.

The Mesolithic in Britain, as conventionally described in the literature, spans a little under six thousand years, beginning around 9500 cal BC. It ended in Britain around 3800 cal BC, with the introduction of domesticated species. This is, of course, arbitrary, with continuity both before and after (papers in Bailey and Spikens 2008; and Whittle and Cummings 2007). The Mesolithic in Britain is usually associated with, and indeed for many defined by, the presence of microliths, small flint blades, and bladelets. It is also a period associated with, and again frequently defined by, rapid environmental change. The period witnessed the open, deglaciated landscape change as coniferous and deciduous woodland developed over time. Associated with this, as this thesis sets out, was the rapid rise in sea-levels, which inundated a large part of the landscape.

This thesis aims to understand this Mesolithic landscape, that is, the area now below the North Sea and English Channel (also known as La Manche in French and referred to here as Channel/Manche), and the experience of environmental change that occurred as a result of sea-level rise. This was change that profoundly altered ecosystems and habitability in coastal regions and ultimately led to the displacement of communities as land was submerged and lost altogether. Further, this process occurred exactly where a large percentage of the population are likely to have been located and drawn to, not least for the rich coastal resources, but also for transportation, communication and for other social and cosmological reasons. Although varying from place to place, the effects of sea-level rise will have caused, at times, severe social and economic problems.

Sea levels have always varied, going up and down by as much as 100–150 m over hundreds of thousands of years as Quaternary ice sheets have grown and decayed. Levels are changing still now, increasing at a rate that should alarm us all, and will continue to change, in both directions, in the future. They are, in short, dynamic.

Most theses on early Holocene sea-level rise (and there are a fair number) are explicitly scientific and mostly under the aegis of Physical Geography. Typically the researcher conducts fieldwork, usually coring, and uses the resultant data to add to and improve a broader sea-level curve. While these studies are necessary and important, few have the space or inclination to consider the social consequences of sea-level rise, which is the focus of this thesis.

This work explicitly does not focus on individual case-studies, but is a wide-ranging study that makes use of the broader literature on the subject. It focuses on social aspects – on how people perceived and responded to sea-level rise. To do this I have cast my net wide to take in modern sea-level studies from a broad set of ethnographies from around the world. The evidence has come from anthropology, geography, biology, sociology and philosophy, and has required an understanding of hydrodynamics, disaster studies, cognitive science and much more. I have taken the southern North Sea and Channel/Manche as my study area, incorporating archaeological evidence from offshore locations, but have also used the evidence from the countries surrounding it.

The southern North Sea forms a semi-enclosed basin on the European Continental Shelf, bounded to the west by the United Kingdom and to the east by mainland Europe. It is open to the north and there is a narrow outlet to the south, through the Dover Straits, from which the Channel/Manche flows. Water depths are now between 40 and 80 m, although they can exceed 130 m over deep valleys and channels.

One of the challenges for this work has been to collapse oft repeated dualisms: nature and culture, mind and body, subject and object. In that sense it is an attempt to reconnect the chasm between the social sciences and the natural sciences. And this thesis, in a very fundamental way, is about human-environment relations; sea-level rise being a lens through which to focus on these relations. Alongside this, I have aimed to bring the person back into archaeological discourses on past sea-level rise.

This thesis joins a growing body of literature that argues that a major theoretical reorientation within Mesolithic studies is imperative; one that focuses as much on the social as the economic, reconceptualising nature and culture as one. Within discussions of Mesolithic environmental change, this thesis is an attempt to provide the basis for such a reorientation.

Doing this doctoral research part-time has meant that I have had six years to think about it and evolve my thoughts and ideas. I have had the time to explore very diverse literature across disparate disciplines. I have watched and listened to television and radio programmes and read newspaper articles about sea-level rise; and I have been stimulated by lectures and discussions. These have all influenced me in one way or another and the themes are threaded throughout the thesis.

Much has changed over this time too. When I started, the huge amount of information from the University of Birmingham's North Sea Palaeolandscapes Project seismic survey was yet to be published. Back in 2007, no similar study on the social aspect of sea-level rise in the North Sea was being undertaken and the subject seemed novel. A year after I started, however, doctoral research on a similar theme was started at the University of Southampton (Dewing 2013). Later, another thesis began at the University of Birmingham using recent seismic survey work to better understand the social impacts of the loss of land as a result of sea-level rise (Fitch 2011). Realising that they would both complete before me, I had to ensure that my thesis was sufficiently different and nuanced to minimise overlap and maintain its novelty.

Much has changed with me too. Eight weeks after I registered at Manchester to undertake doctoral research in April 2007, and at short notice, I took over the management of the archaeological fieldwork at Silbury Hill; a project that was to dominate my work programme, and indeed my life, since. Further still, over this time I have married, moved house twice, had a daughter, and then another. Free time became special and working evenings and weekends difficult.

Nevertheless, this research has been much fun and worth every minute of the effort. It was a launch into the unknown, with all the attendant highs and lows, the 'eureka' moments and dead ends. And now, having reached an important point in this journey of discovery, I am, like the world and environment around us, much changed.

A note on the radiocarbon dates used

One of the challenges of the datasets used in this thesis is that researchers reference dates in a variety of ways, from uncalibrated radiocarbon bp and bc dates to calibrated BP and BC, sometimes varying even within the same paper. I have chosen to use calibrated BC dates throughout (referenced as cal BC), and have calibrated any bp dates (referencing where I have done so) using OxCal 4.1 (c14.arch.ox.ac.uk/oxcal/OxCal.html) and rounding the dates up or down as appropriate and taking the midpoint of the rounded date range.

Abbreviations

LGM – Last Glacial Maximum

MALSF – Marine Agreggates Levy Sustainability Fund

m OD – metres above Odnance Datum

NGF – Nivellement Generale Francais

RCHME – Royal Commission on the Historical Monuments of England

REC – Regional Environmental Characterisation

RSL – Relative Sea-Level

SLIPs – Sea-Level Index Points

Chapter 1

Recognising Northsealand

"We begin, therefore, with a period when the whole of the southern part of the North Sea was an alluvial flat connecting Britain with Holland and Denmark, and to some extent with France. The Isle of Wight was connected with Hampshire, and the Channel Islands with France" (Sir Clement Reid 1913, 106).

1.1 Introduction

"A very remarkable circumstance occurred." wrote Gerald of Wales at the end of the twelfth century. "The sandy shores of south Wales, being laid bare by the extraordinary violence of a storm, the surface of the earth, which had been covered for many ages, reappeared and discovered the trunks of trees off standing in the very sea itself, the strokes of the hatchet appearing as if made only yesterday. The soil was black and the wood like ebony … like a grove cut down, perhaps at the time of the deluge" (Giraldus Cambrensis 1191, 1908 edition).

This is the first published recognition of a submerged landscape in Britain and clearly, according to Gerald, evidence for the biblical flood. It was not, however, until the eighteenth and nineteenth centuries that research on submerged forests really developed, when eminent scientists such as Charles Lyell, Thomas Huxley and William Boyd Dawkins were spurred on by debates over the biblical flood and the age of humanity. As early as 1897 Sir John Evans wrote of an isthmus connecting Britain with the Continent.

As the British shipping industry reached its climax towards the end of the Victorian period, dock excavations increased and led to the recovery of peats in the mouths of river ports (Bell 2007). These were observed by the British Geological Survey and published in 1913 by a pioneer of palaeobotany, Clement Reid. Reid recognised them, by virtue of associated finds, as pre-dating the Bronze Age (Reid 1913). Insightfully, he wrote of the submerged forests and peats around the coast of Britain:

> “the geologist should be able to study ancient changes of sea-level, under such favourable conditions as to leave no doubt as to the reality and exact amount of these changes. The antiquary should find the remains of ancient races of man, sealed up with his weapons and tools. Here he will be troubled by no complications from rifled tombs, burials in older graves, false inscriptions, or accidental mixture. He ought to here find also implements of wood, basketwork, or objects of leather, such as are so rarely preserved in deposits above the water-level” (Reid 1913, 9).

As the quote at the start of this chapter shows, Reid interpreted the area of the southern North Sea as a vast alluvial plain connecting Britain with the Continent, with the Dogger Bank as dry inhabitable land, the size of Denmark, rising up out of the northern edge of the plain (Reid 1913). The seventh edition of John Lubbock’s ‘Pre-historic Times’ was also published in 1913, and, using much of the emerging information, he briefly discussed the evidence for submerged activity. In contrast to Reid, Lubbock referred to a much earlier geological period and illustrated the low sea-level on a map (Lubbock 1913, fig. 255). Even before this, however, a land connection between Britain and Europe had established itself in the public consciousness, or at least in the minds of numerous school children, when in 1911 Rudyard Kipling wrote of the River Thames in his poem ‘The River’s

Tale' for the school book '*A History of England*' (Fletcher and Kipling 1911, 9):

"I walk my beat before London Town,
Five hours up and seven down.
Up I go and end my run
At Tide-end-town, which is Teddington.
Down I come with the mud in my hands
To plaster it over the Maplin Sands.
But I'd have you know that these waters of mine
Were once a branch of the River Rhine,
When hundreds of miles to the East I went
And England was joined to the Continent."

By the 1930s and 1940s Sir Harry Godwin was pioneering his analysis of pollen from coastal peat beds and using them as indices of sea-level change (Godwin 1943). In 1931, a lump of peat was dredged from the depths of the southern North Sea by the 'Colinda' between the Leman and Ower Banks (at a depth of about 36 m), which contained within it a barbed antler point (Burkitt 1932; Fig. 1.1). Godwin recognised the importance of this find and surmised that it must have come from dry land when this existed between Britain and the Continent.

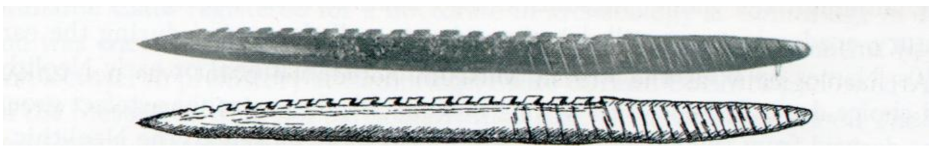


Fig. 1.1: The Colinda antler point (length 21.6cm). (From Gaffney *et al*. 2009, 15).

In 1936 Grahame Clark's seminal book '*The Mesolithic Settlement of Northern Europe*', drew on the earlier work of Reid and Godwin, recognizing the potential that the area of the southern North Sea was the heartland of the early Mesolithic Maglemosian culture (Clark 1936; Fig. 1.2). While he did not speculate on the detail of this land or the communities that lived there, he did suggest that the period could not be fully appreciated without considering it (1936, 86–7). Clark continued to stress the importance of the North Sea area for Mesolithic European cultures in subsequent publications, emphasising that Britain had "throughout history … stood at the corner of Europe benefitting by influences … from a variety of continental sources" (Clark and Rankine 1939, 98). He also later referred to the impact the loss of land may have had on contemporary populations (1975, 28).

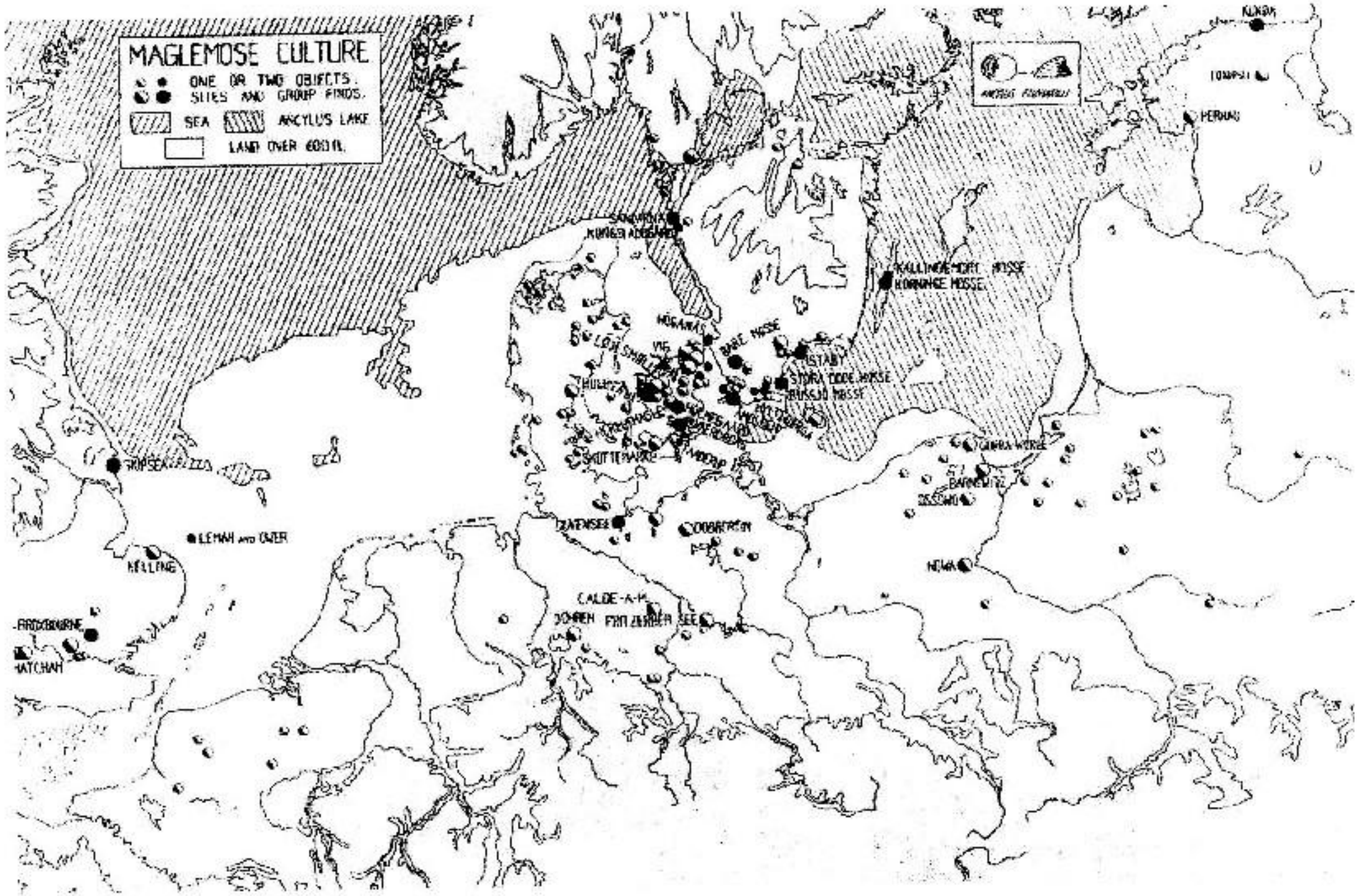


Fig. 1.2: Clark's map of the Mesolithic landscape of the southern North Sea. (From Clark 1936).

1.2 Palaeogeographies, palaeoenvironments and sea-level curves

Despite Clark's mention of a Mesolithic 'heartland', from the 1960s discussions of the inundation of the North Sea lowlands focused not on the cultural aspects, but on scientific studies of sea-level change. Curves representing Holocene sea-level rise were produced by radiocarbon dating of intertidal peats. Peat obtained by the Colinda was dated in 1960, showing it to be 7950–7050 cal BC, although this was not necessarily the same peat the antler point was recovered from (Gaffney *et al*. 2009). The antler point, in fact, returned the unexpectedly early date of 11,850–11,350 cal BC (Godwin 1960; Ward *et al*. 2006, 215).

The first sea-level curve to rely on radiocarbon dates was published by Jelgersma (1961), and further work resulted in a number of significant palaeogeographic reconstruction maps showing major coastline changes from *c*. 19,000 cal BC to *c*. 7400 cal BC (Jelgersma 1979; dates subsequently calibrated using OxCal 4.1). However, the spatial and temporal variations of relative sea-level across the region were very poorly constrained, and this significantly limited the accuracy of the reconstructions.

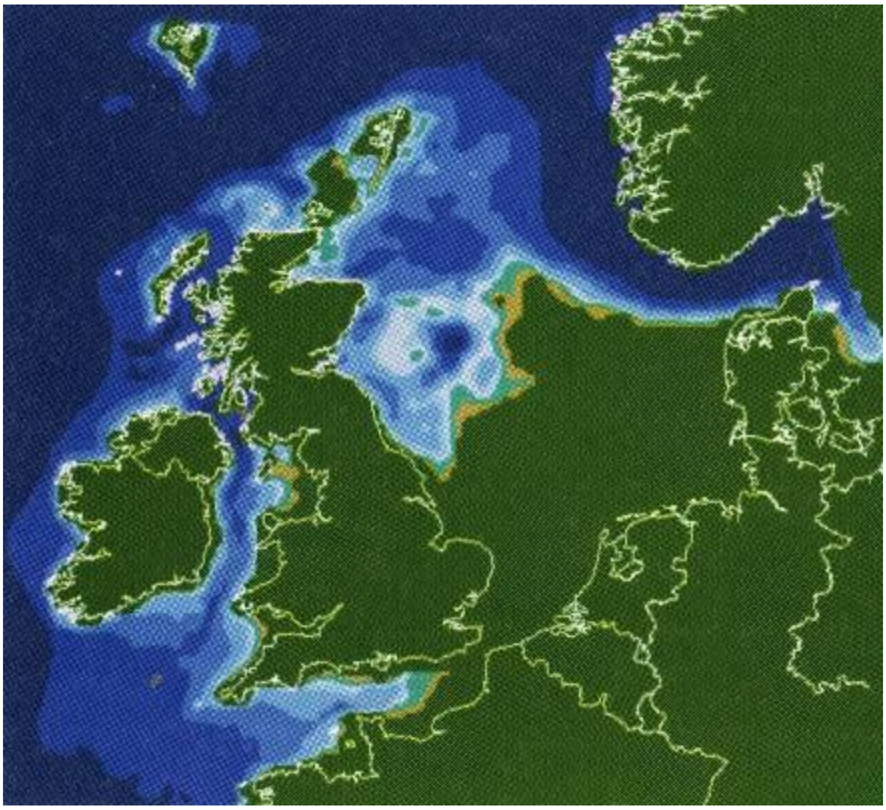
Further work on palaeogeographies of the area was undertaken by Lambeck (1995), Coles (1998) and Shennan and Andrews (2000). Lambeck modified the Jelgersma (1979) reconstructions by incorporating isostatic rebound models (1995), whilst Coles deliberately did not revise the Jelgersma 1979 map. Instead, she produced a new one, also based on bathymetry, but which was much more explicitly hypothetical (indeed, the title of the paper '*Doggerland: A speculative survey*' acknowledged this)

(Coles 1998). Coles' paper was an important step since it put, for the first time, the inundation within a human perspective (and this is discussed further below).

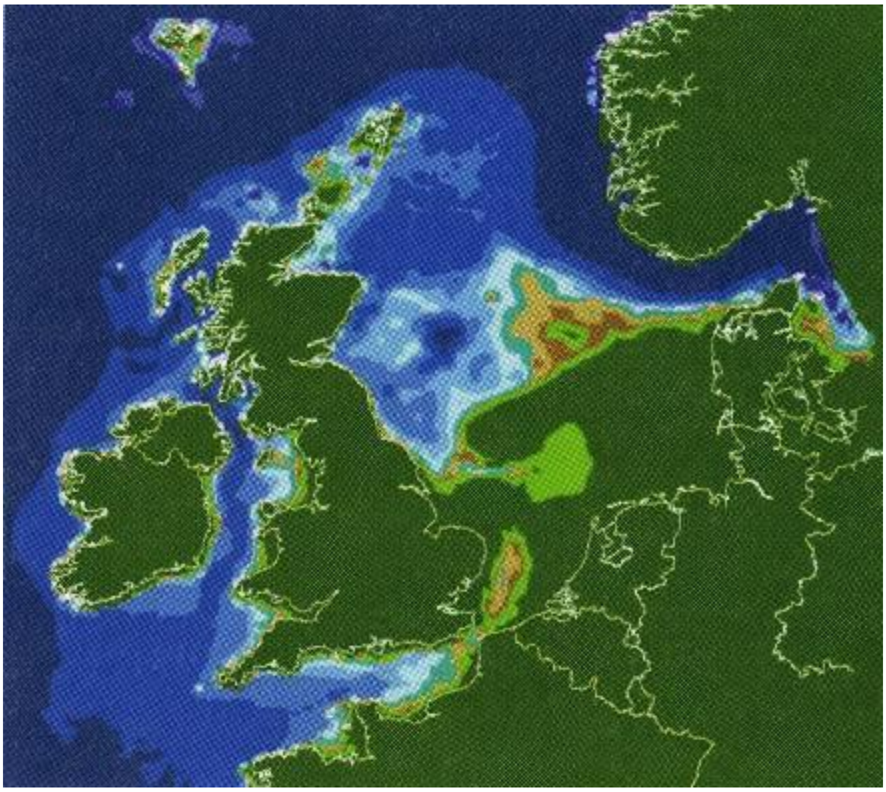
Shennan and Andrews (2000) undertook work under the banner of the 'Land Ocean Interaction and Environmental Change around the North Sea' (LOIS) project. This combined isostatic factors with eustatic changes in ocean volume to produce regional-scale relative sea-level changes. It was based on the analysis of sea-level data from the east coast of England, primarily the Humber Estuary, Northumberland, the Tees Estuary, Lincolnshire Marshes, Fenland, and north Norfolk (Shennan and Andrews 2000).

Using these data, and helped considerably by increases in computer power, the LOIS team identified variables that explain spatial and temporal unevenness. This included modifications in the tidal regime along the estuary and the relationship between the freshwater table and tide levels (Shennan and Andrews 2000). The data were then imported into a GIS database to produce a new series of palaeogeographic reconstruction models of the western North Sea in the Holocene (Fig. 1.3).

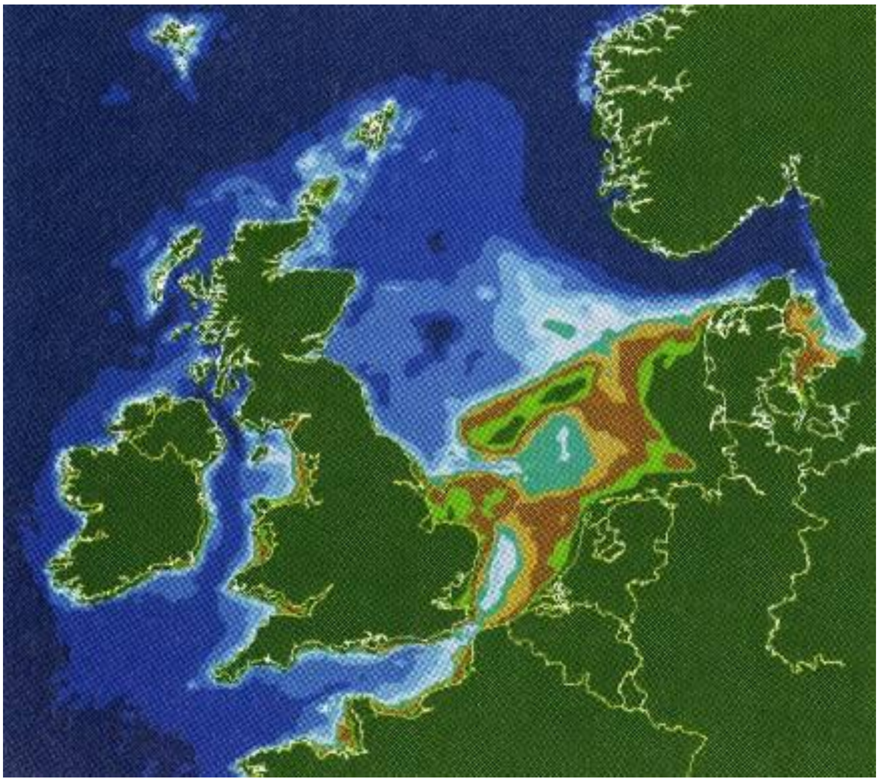
These reconstruction models suggest that at the start of the Holocene the North Sea coastline ran from Denmark to eastern England and with an embayment on the west side, which extended south to Flamborough Head. As sea-levels rose, the maps predict that this embayment extended south and then east to produce a shallow estuary south of the Dogger Bank around 8250 cal BC, while another embayment pushed east along the English Channel, and then northwards past the Dover Strait. This eventually linked with the North Sea via a narrow strait northeast of Norfolk around 6400 cal BC. In this model the Dogger Bank was cut off from the mainland during high tides at this time, and by the beginning of the sixth millennium cal BC was perhaps only exposed at low tide. It finally became entirely submerged by the beginning of the fifth millennium cal BC. By this time, the western margins of the North Sea are marked on the reconstruction map as close to the present coastline (Shennan and Andrews 2000; Shennan and Horton 2002; dates calibrated using OxCal 4.1).



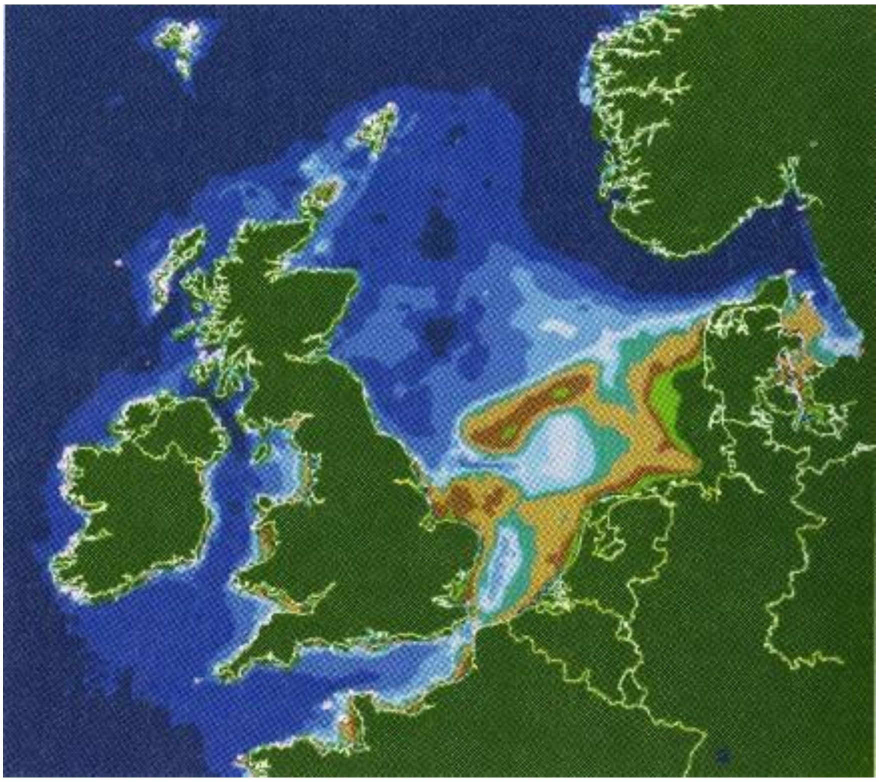
c. 9500 cal BC



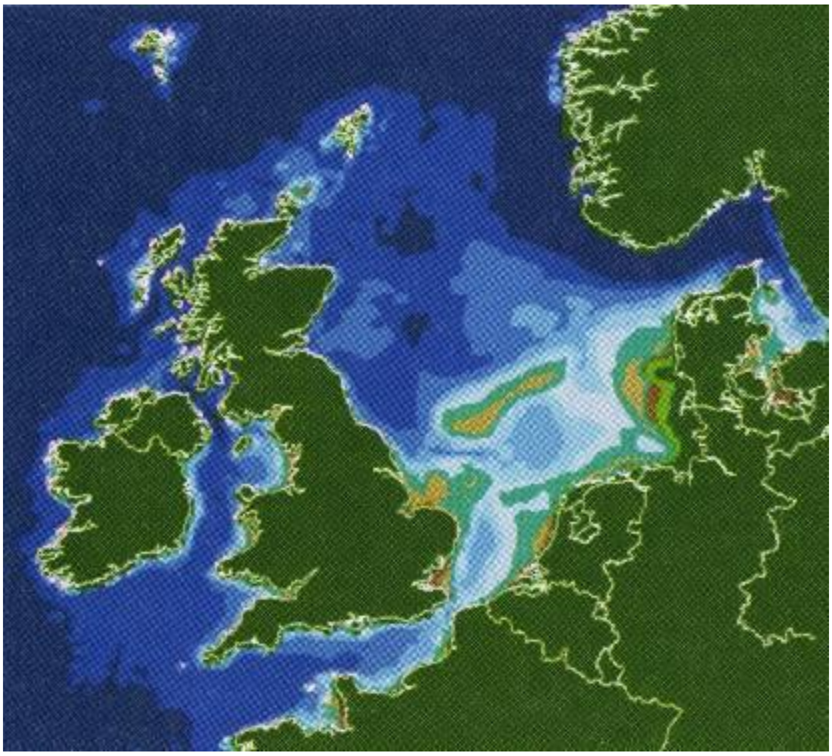
c. 8250 cal BC



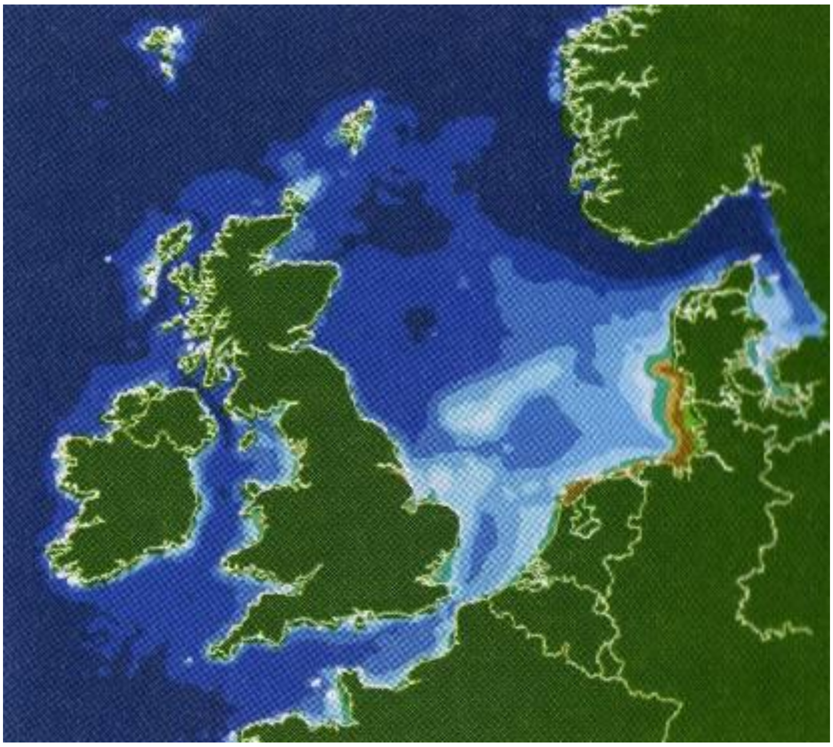
c. 6900 cal BC



c. 6400 cal BC



c. 5900 cal BC



c. 4900 cal BC

Fig. 1.3: Palaeogeographic reconstructions produced by the LOIS team. (From Shennan *et al*. 2000, 310–1). (Dates calibrated using OxCal 4.1).

These reconstruction models were based on present-day bathymetric data; that is, the depth and form of the seabed below the surface. Bathymetry can, however, bear little relationship to submerged Holocene landscapes, since major features can be many metres below, and masked by, the present seabed (Fitch *et al*. 2005; Gaffney *et al*. 2007; 2009).

Significant advances have been made in the last few years in overcoming such discrepancies by using the vast 3D seismic data sets developed by the petroleum industry to explore the deep geology of the continental shelf. The data sets have extensive regional coverage and good spatial resolution (12.5m) allowing parts of the Holocene topography to be mapped in some detail. These show that the previously published palaeogeographic reconstructions require considerable revision (Fitch *et al*. 2005; Fitch 2011; Gaffney *et al*. 2007; 2009; Gupta *et al*. 2004; 2007).

Funded by the Marine Aggregates Levy Sustainability Fund (MALSF) (see Chapter 7 for more on this), Birmingham University demonstrated the usefulness of such data when they undertook a study of one area around the Outer Silver Pit in the southern North Sea (for the location of the Outer Silver Pit see Figs. 1.9–13 below. It is also discussed in detail in Chapter 4).

By time-slicing the data at four metre intervals and using rendering and visualisation techniques, it was possible to see clear three-dimensional images of buried features, such as valleys, river channels and lakes. These could then be integrated into GIS (Fitch *et al*. 2005; Fitch 2011; Gaffney *et al*. 2007; 2009). A similar methodology, using sidescan sonar survey and sub-bottom profiling, combined with vibrocoring and grab sampling, has also been employed in the Channel/Manche by Wessex Archaeology, and again supported by the MALSF, as part of the 'Seabed in Prehistory' project (Gupta *et al*. 2004; 2007).

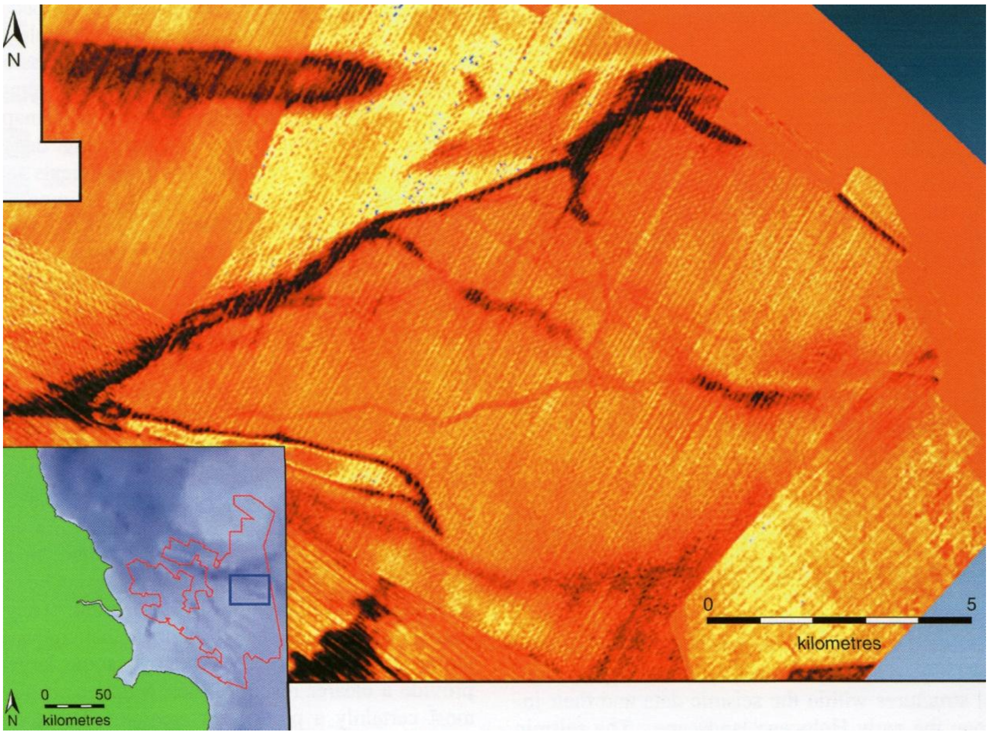


Fig. 1.4: A seismic timeslice from the eastern side of the NSPP study area showing palaeochannels within a wetland plain. (From Gaffney *et al*. 2007, 85).

Meanwhile, the sea-level curve has been further improved by dating peat from both recent dredging as well as more systematic sampling, such as from vibrocores (Ward *et al*. 2006; Behre 2007). Peats have been recorded from both onshore and offshore locations, such as around Dogger Bank, German Bight, Well Bank, Sandettie-Fairy Bank (see Fig. 1.5 for approximate bank locations), as well as the Channel/Manche. Helped significantly by the development of the English Heritage Intertidal and Coastal Peat Database (Hazell 2008; Bicket 2012; Fig. 1.6), these peats can provide a wealth of information on the past environment, often revealing the transition from freshwater to salt-marsh that accompanied sea-level rise. They also provide a range of radiocarbon dates (Fig. 1.7), which help refine the sea-level curve further. Those published by Ward *et al*. (2006), largely concur with Shennan and Andrews (2000), indicating salt water conditions from 6050 cal BC, and that fully marine conditions prevailed from about 4550 cal BC.

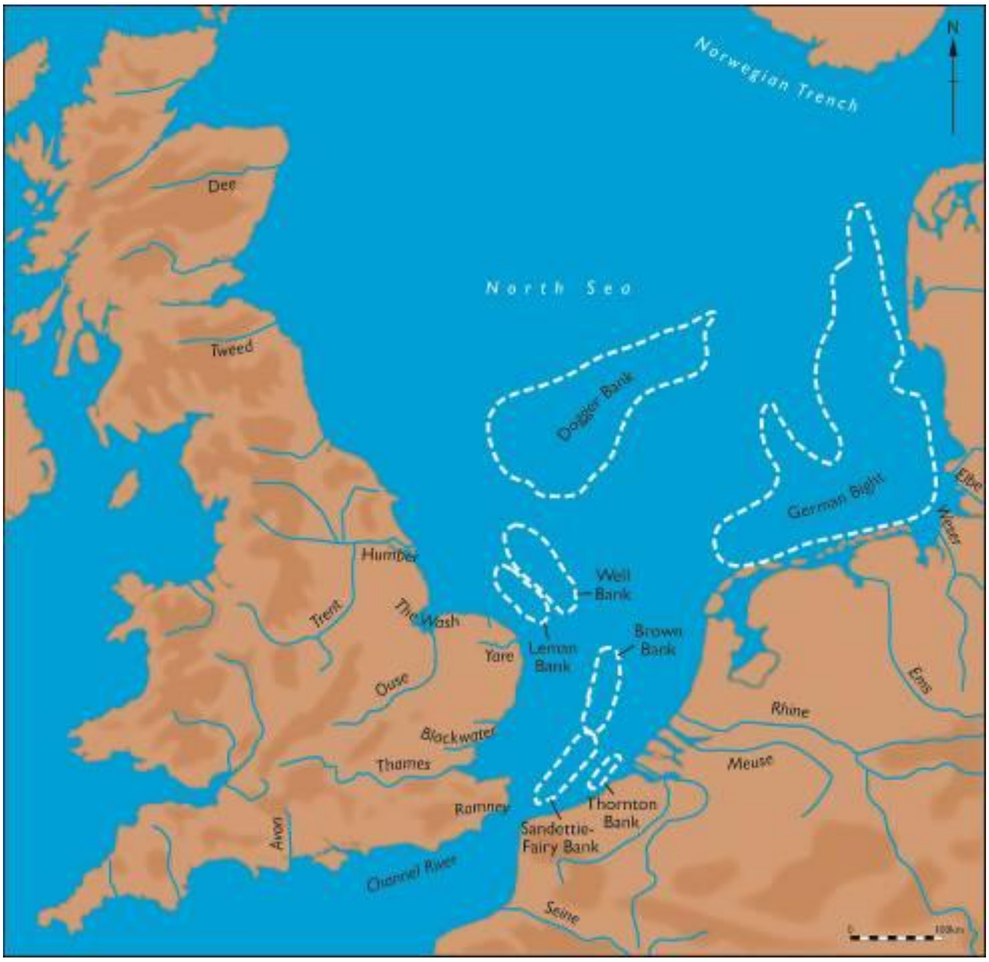


Fig. 1.5: Named sand banks within the southern North Sea.

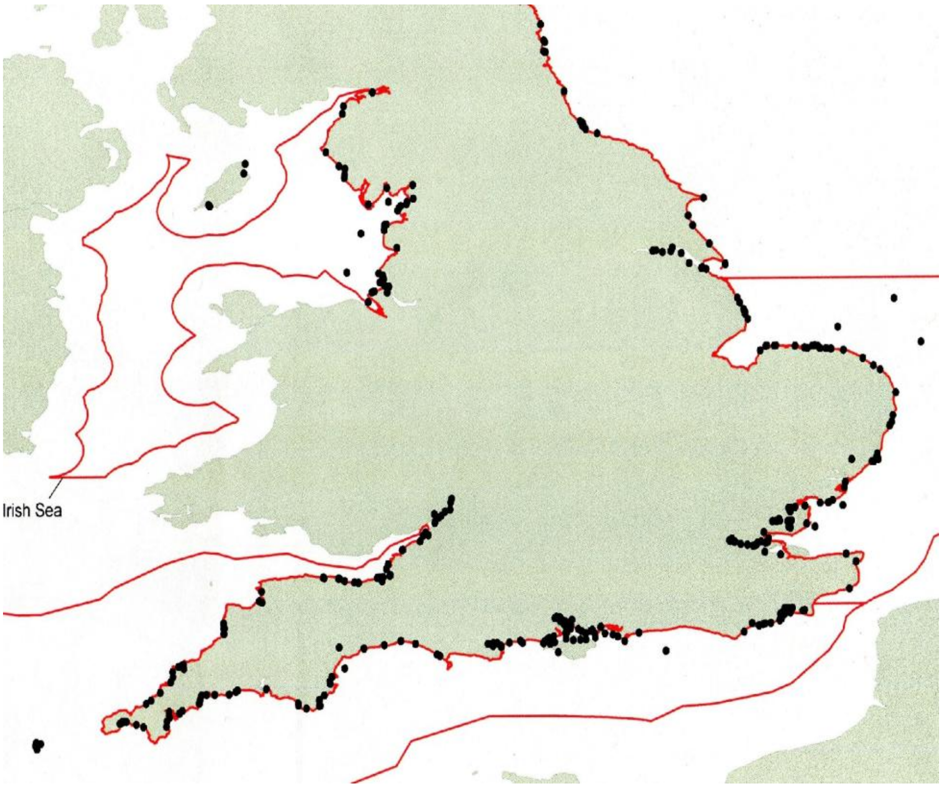


Fig. 1.6: Location of intertidal and offshore peat deposits within British waters around the UK. (From Bicket 2012, fig. 5).

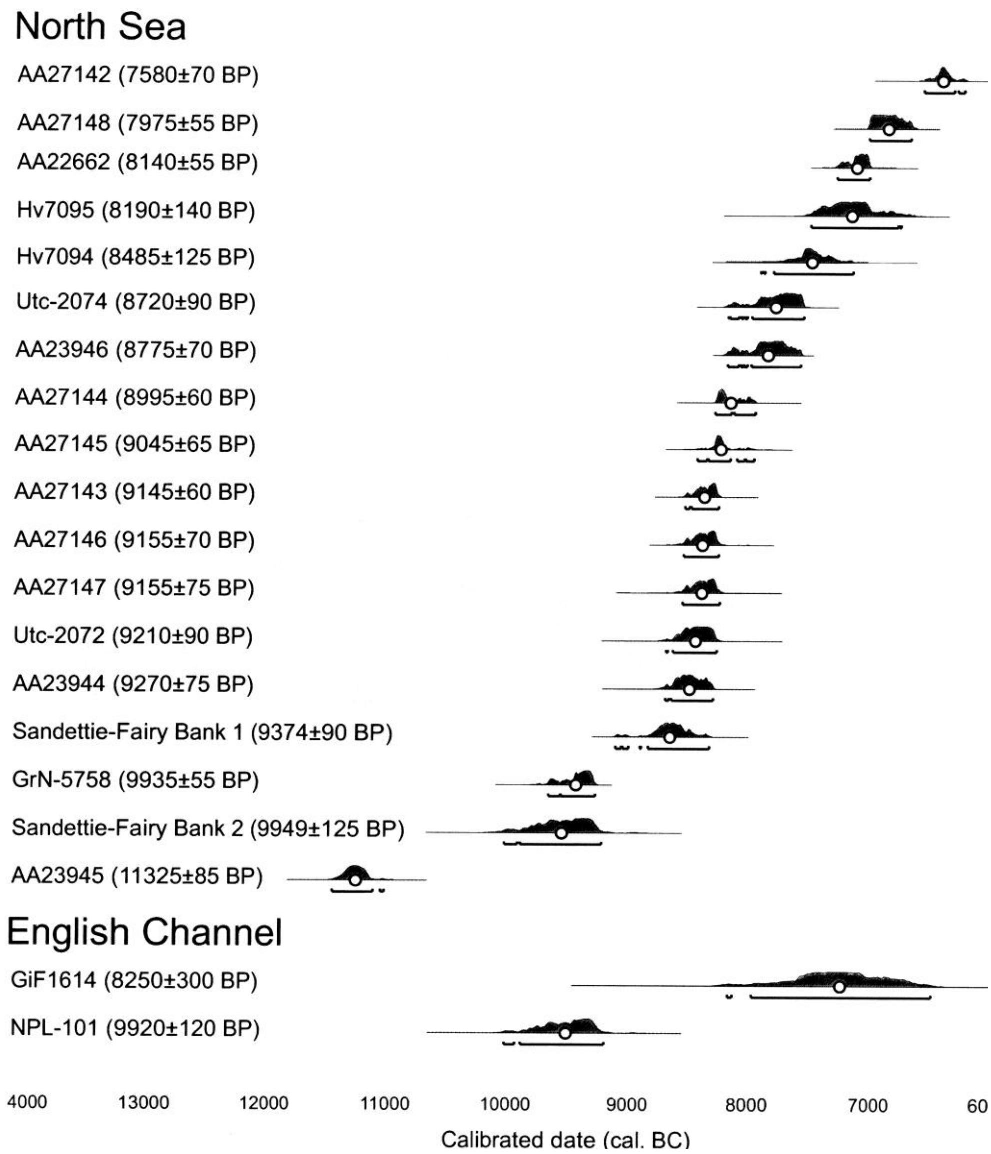


Fig. 1.7: Dated offshore peat deposits within British waters in the southern North Sea and Channel/Manche. (From Bicket 2012, fig. 6).

Behre (2007) has set out a refined sea-level curve based on new dates obtained along the German coast (Fig. 1.8). This indicates that the North Sea had extended around the southern part of the Dogger Bank by 9000 cal BC, which became an island “more than a thousand years later” (Behre 2007, 99). In this interpretation a connection was made between the North Sea and Channel/Manche via the Southern Bight around 7000 cal BC and fully marine conditions were reached after 6000 cal BC (Behre 2007) (see Figs.1.9–1.13). From 5000 cal BC the rapid sea-level rise slowed down; the curve becoming more horizontal and with numerous oscillations representing regressions and transgressions (Behre 2007) (Fig. 1.8).

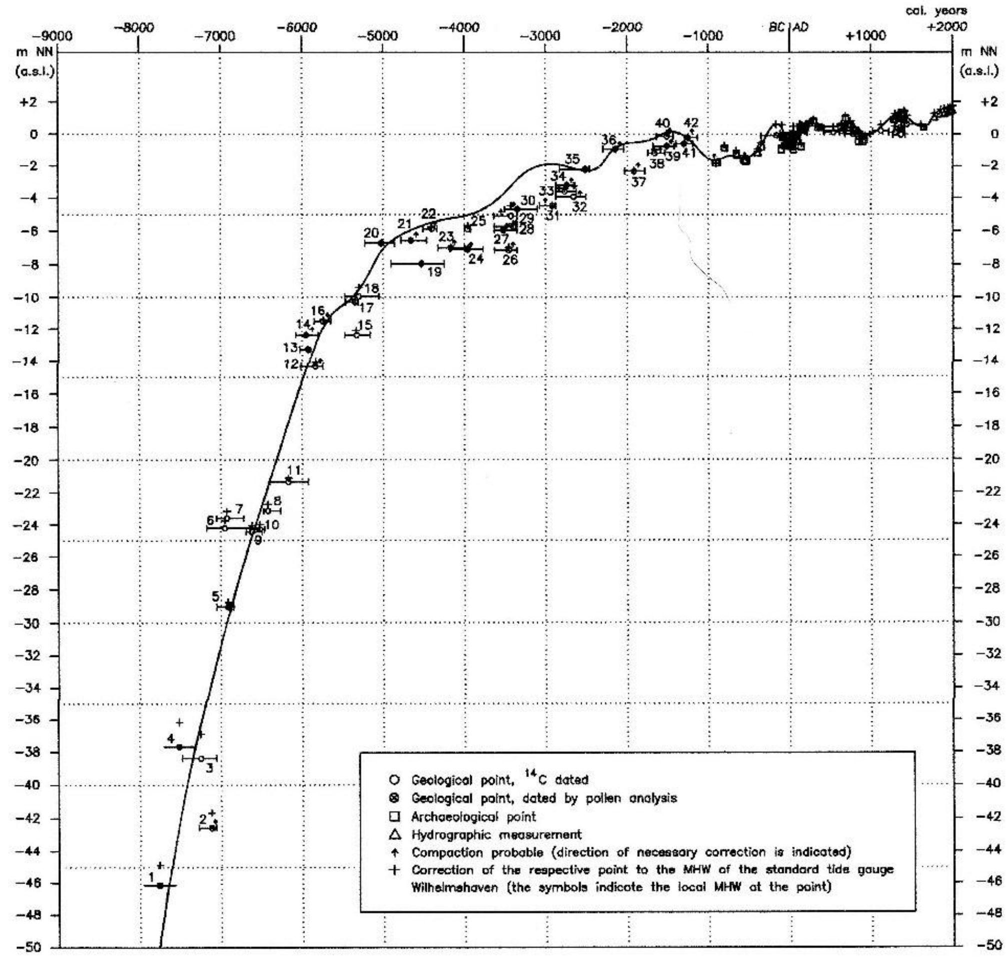


Fig. 1.8: Holocene sea-level curve showing sea-level changes (MHW) and calibrated dates in the southern North Sea. (From Behre 2007, 84).

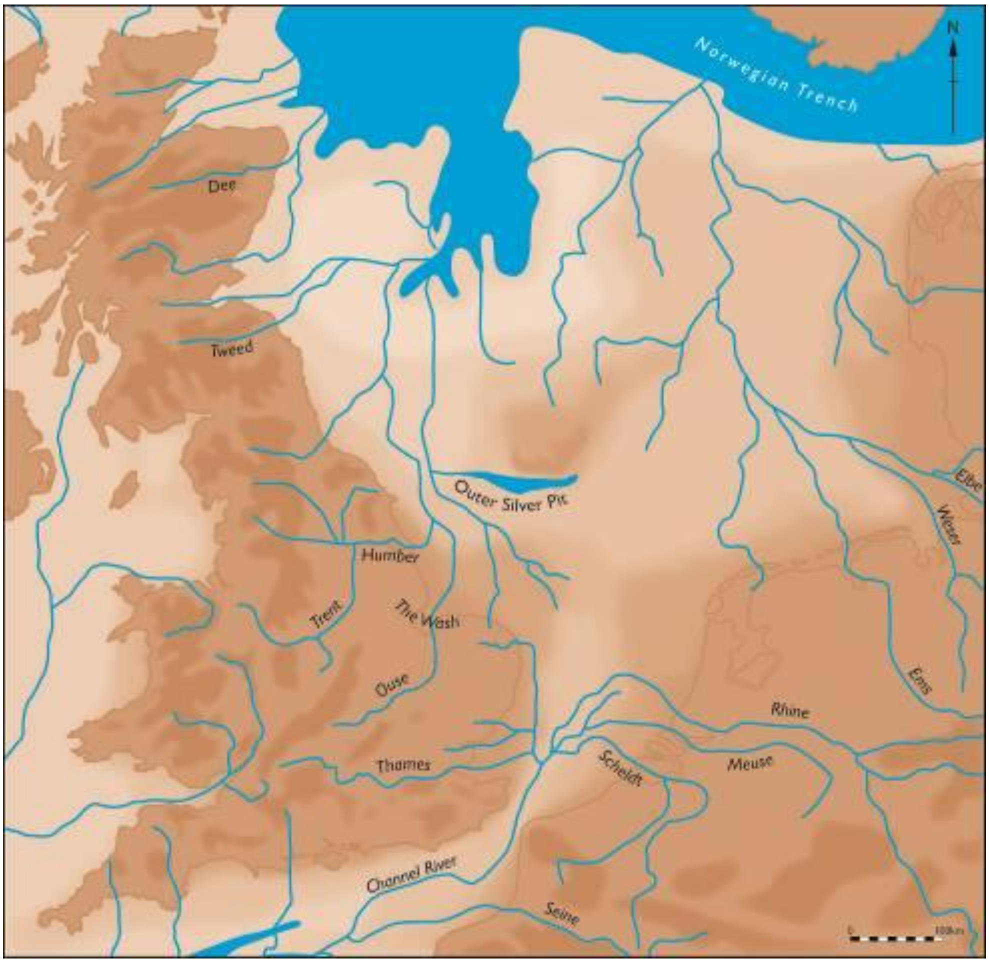


Fig. 1.9: The suggested coastline at 12,000 cal BC. (Based on Behre 2007).

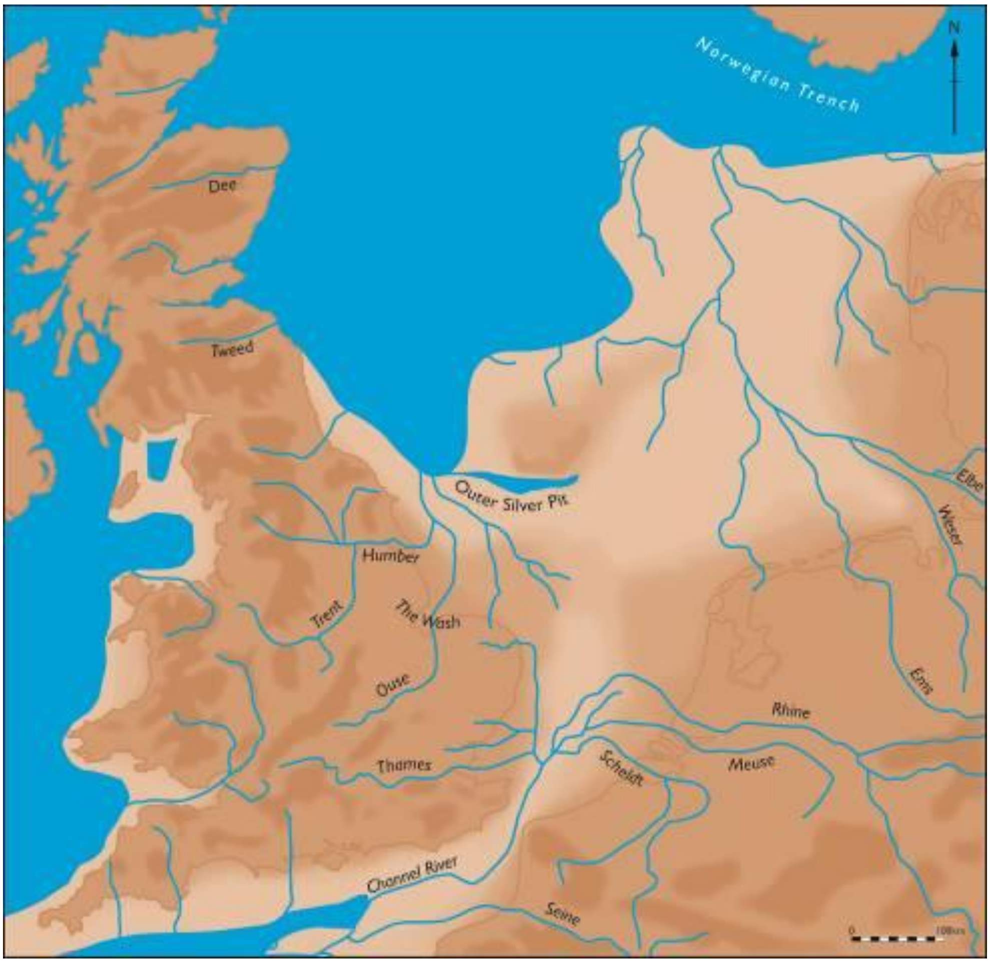


Fig. 1.10: The suggested coastline at 9600 cal BC. (Based on Behre 2007).

Fig. 1.11: The suggested coastline at 7200 cal BC. (Based on Behre 2007).

Fig. 1.12: The suggested coastline at 6800 cal BC. (Based on Behre 2007).

Fig. 1.13: The suggested coastline at 6000 cal BC. (Based on Behre 2007).

1.3 Sea-level rise, the Mesolithic period, and society

Although the second half of the twentieth century saw a focus on the production of sea-level curves, the archaeological implications were not entirely ignored in the literature. Morrison (1980) discussed the North Sea area as a centre of the Mesolithic culture, emphasising the rich resources that would have been present and which could have supported a large population. Smith (1992), too, described this area and used the available palaeoenvironmental information to map the vegetation of the North Sea plain.

There remained, however, a tacit acceptance amongst many researchers that it represented little more than a land bridge between the two occupied landscapes of Britain and the Continent (Coles 1998, 50). It was seen as a passive corridor that allowed people and animals to move on their way from one side to the other, but not an area to live in – to settle, hunt, gather, tell stories, and raise children. Jacobi (1976a), for example, discussed the land between Britain and the Continent as a cultural link, the loss of which should be traceable through technological changes (discussed further below).

This issue was brought to the fore in 1998 by Coles in a seminal article in which she discussed the Holocene landscape of the North Sea plain. She also named the area *Doggerland* in recognition of Reid's description of Dogger Bank rising from the surrounding landscape (although see the alternative name used in this thesis below). Coles, in many ways echoing Clark (1936), challenged the prevalent assumption that the area was a land bridge between two inhabited landscapes of Britain and Europe.

Rather she described it as an area that could have supported large populations who had easy access to resources.

Since Coles' 1998 paper, and subsequent articles (1999; 2000; and 2013 for a retrospective), the archaeological importance of the southern North Sea in terms of its social and cultural significance has grown. This is reflected in the more recent literature (for example papers in Flemming 2004; Rensink and Peeters 2006; Waddington and Pedersen 2007; Gaffney *et al*. 2007; 2009; Peeters *et al*. 2009; Benjamin *et al*. 2011; Van de Noort 2011a).

However, despite greater discussion of the social aspects of the North Sea lowlands, there has been surprisingly little on how such drastic landscape changes would have affected the lives of those dwelling there. As Chapman and Lillie (2004) highlight, there is not much in the literature discussing the way people either perceived or responded to these events. Attempting to address the first of these points Chapman and Lillie modelled sea-level rise in Holderness, East Yorkshire. They successfully demonstrated that a continuous sea-level rise resulted in little initial landscape change, but was followed by rapid and easily perceptible inundation.

The few other discussions of Mesolithic perceptions and responses to sea-level rise have tended to be rather one dimensional. Coles saw the expanding estuarine habitat as compensation for the loss of land (Coles 1998, 76), while Gaffney *et al*. (2007) describe the inundation as forming a devastating backdrop to Mesolithic life. As set out in the next chapter, both these descriptions leave us with a general sense that all people perceived and responded to environmental change in equal measure. Further, Coles' description, on the face of it, assumes that Mesolithic people were 'at one' with nature or even perhaps part of nature. Gaffney *et al*. on the other hand imply that environmental change is something externally imposed and beyond society's control (framed as culture pitted against the ferocity of nature) (Chapter 2).

The overall lack of engagement with the social implications of the inundation of the North Sea lowlands is, perhaps, largely the result of the inaccessibility of the area and its archaeological deposits. Maritime archaeology has emerged as a distinct sub-division of archaeology; however it has tended to focus on the somewhat more alluring and high-profile shipwreck sites. Although things are changing now, wetland archaeology and the study of submerged landscapes, have, relative to this, been somewhat more isolated (Van de Noort and O'Sullivan 2006; Menotti 2012; Menotti & Sullivan 2013; Tyson *et al*. 1997). This is despite the excellent levels of preservation with enormous potential for understanding past landscapes.

Furthermore, the geographical area of the North Sea has previously fallen outside both Britain and the Continent, and has, until recently, attracted little archaeological interest from either side. Clement Reid also predicted in 1913 "the archaeologist is inclined to say that [the deposits] belong to the province of geology, and the geologist remarks that they are too modern to be worth his attention; and both pass on" (Reid 1913, 3). The North Sea lowlands, a Mesolithic landscape larger than the United Kingdom, therefore, fell through a gap on a number of counts.

Similarly, problems have been caused by the perceived insularity of Britain in the later Mesolithic, focussing attention away from the social implications of inundation. This has been most clearly articulated in discussions of lithic technologies with research concentrating on Britain's technical (and therefore the implied cultural) separation from Europe (Jacobi 1976a; 1979). The North Sea and Channel/Manche are thus seen as a hindrance, emphasising the importance of Britain as an island, and arguably perpetuating a modern pre-conceived idea of what it is to be British.

However, more recent studies of Mesolithic lithic types show that style-zones emerge across north-western Europe at broadly the same time (Gendel 1984; Reynier 2005). The appearance of Jacobi's style-zones does not, therefore, necessarily indicate a British isolation, but forms part of a more wide-spread phenomenon. In any case, the coincidence of the different types of lithics with the final 'cutting-off' of Britain from the rest of Europe is far from proven (Thomas 2007).

Furthermore, as Fitch *et al*. (2007a, 106; Fitch 2011) point out, the potential for communication by boat following the inundation is just as likely to enhance contact than reduce it; as the Norwegian saying goes "the land divides us but the sea unites us" (Gaffney *et al*. 2009, 147). Mesolithic studies on the Continent have also developed separately, resulting in differences in terminology and nomenclature, and indeed are published in many languages, hindering a more holistic view of the North Sea region.

Problems have also persisted due to a lack of engagement with the social aspects of the Mesolithic period in general, the period sitting awkwardly between the better researched Palaeolithic and Neolithic periods. Westropp (1872) introduced the term to describe not a cultural epoch but a period in time between the Palaeolithic and Neolithic periods (Rowley-Conwy 1996; Milner and Woodman 2005a; Zvelebil 2009; Price 1987), and the term 'Mesolithic' was used only sporadically in the late nineteenth century and early in the twentieth (*eg* Brown 1893; Read 1911, 347; Burkitt 1925; 1926; 1932; Macalister 1921).

Vere Gordon Childe may be largely responsible for popularising the Mesolithic as a period of both continuity and degeneration. In *Man makes himself* he stated that: "since economically the Mesolithic Age was a mere continuance of the Old Stone Age mode of life, it has seemed needless in this book to complicate the picture with a Mesolithic" (1936, 50). The Mesolithic period fared little better in his next book *What happened in history*, although it did receive a few pages of discussion, introduced thus: "by contrast to what had passed away, the mesolithic societies leave an impression of extreme poverty" (1942, 50–1). Childe maintained throughout his lifetime (1957; 1958) that, as a term, the Mesolithic represented nothing more than a transition between the Palaeolithic and Neolithic.

Grahame Clark too described the Mesolithic as "a term of chronological significance denoting cultures that flourished between the Palaeolithic and Neolithic in point of time" (1952, xiv). For him, the period "bridged the old hunter-fisher mode of life to one based on the new economy of farming" (1961, 63), and suggested "the Mesolithic peoples can be considered as transitional …" (1961, 67). Stuart Piggott too described them as "an intermediate group" in 1965 (25).

The ‘middle’ in ‘middle Stone Age’ was neither conducive nor attractive to researchers or the public and remained, relative to the Palaeolithic and Neolithic periods, under-researched (Zvelebil 1986a; Rowley-Conwy 1986; Spikins 2008). This situation was not helped by comments from eminent archaeologists, such as the description of Mesolithic people as “squalid a huddle of marsh-ridden food gatherers as the imagination could encompass” (Wheeler 1954, 231). As late as 1975 Evans wrote of the Mesolithic:

> “there is nothing of the brilliance of the upper Palaeolithic hunters living as they were in the stimulating landscape of the Ice Age, nor anything of the vital urgency with which later farming communities were to settle and cultivate the landscape of western Europe and the British Isles” (Evans 1975, 90).

The ‘transition’ status for the Mesolithic has undoubtedly had an impact on the way the period has been studied. It being seen as an evolutionary backwater, with the population at the mercy of the environment (see Chapter 2). The traces of this somewhat passive view of the Mesolithic are evident in the dominant twentieth century tropes of Mesolithic Britain, where the inhabitants have been framed almost entirely in terms of economic needs and adaptations.

In these models, which are explicitly ecological and behavioural, hunter fisher gatherers become passive responders to environmental change; they are framed as if they were in a ceaseless struggle with, and at the mercy of, the environment around them (Chapter 2). Often this is contrasted with Neolithic farmers, who are discussed as active, dynamic, domesticating dominators of their environment; a point cogently expressed by Richard

Bradley: "in literature as a whole, successful farmers have social relationships with one another, while hunter gatherers have ecological relationships with hazelnuts" (1984, 48).

To take an example from Childe again – he suggested that "adaptations to the novel and really sterner conditions are represented by so-called Mesolithic cultures" (Childe 1958, 23), and that the "relatively homogeneous Maglemosean culture-cycle broke up into a multiplicity of local cultures, each adapted to the peculiarities of the local environment" (1958, 32). He put this dichotomy between humans and nature most strongly in his discussion of the Mesolithic-Neolithic transition in *What happened in history*; arguing that "the escape from the impasse of savagery was an economic and scientific revolution that made the participants active partners with nature instead of parasites on nature" (1942, 55).

This is a sentiment somewhat echoed by Grahame Clark and Stuart Piggott who, speaking of Australian hunter gatherers, described "the insecurity of their parasitic mode of life" (1965, 106). Childe's use of terms such as 'savage', as with his framing of agriculture as a revolution, was most likely taken directly from his reading of Marx (although see Trigger 1989, 251) and therefore included associated nineteenth century baggage (Trigger 1989, 259–63 for a fuller description of Childe and Marxism).

Grahame Clark combined the study of artefacts with the emerging palynological information to produce an ecological reconstruction of the Mesolithic environment, and fixed the idea that the period was characterised by economic adaptations to environmental conditions (for example 1939; 1952; 1954). This ecological approach saw Mesolithic society as a series of systems functioning to maintain culture in equilibrium (particularly Clark 1952). Developing his approach, Clark (1972) used environmental reconstructions and faunal remains to propose a model for the Mesolithic period. This described lowland base camps (such as Star Carr) exploited in winter and upland hunting camps that followed the herds of red deer in summer. His model thus framed Mesolithic hunters as following their resource.

Clark's ideas of winter-summer movements have been highly influential and his economic and environmentally determined model can be seen in the work of many subsequent scholars. This is particularly so with the notion of upland summer hunting camps and lowland winter base camps (Mellars 1974; 1976; Jacobi 1978a; Myers 1986; 1989; Simmons 1979; 1996; Simmons *et al*. 1981). A more complex and highly influential model was subsequently put forward by Jochim (1976), which took a mathematical approach to resource exploitation in the Mesolithic. It combined a North American ethnographic example with data on the Mesolithic ecology in Germany (Spikins [1999] sets out a full description of Jochim's model and provides a critique of base camp/hunting camp models).

The Cambridge Palaeoeconomy School of the 1960s and 1970s also focused on economic aspects. This school of thought emerged from the work of Higgs (1972; 1975) in particular, and investigated relationships between people and the environment, applying techniques such as site catchment analysis and site territorial analysis. While contributing much to Mesolithic studies at the time, social, cognitive or cosmological notions were not discussed and subsistence strategies over-emphasised.

Lewis Binford and others operating within the framework of New Archaeology also argued strenuously that cultural change in general can be interpreted as an adaptive response to external ecological changes (for example Binford 1962; 1972; discussed in Trigger 1989, 296). An ecological approach to large game exploitation in Finland was also taken by Zvelebil (1981). Adaptation was never far from John Evans' mind when discussing the Mesolithic: "the sheer fact of having to adapt to them [environmental changes] at all must have imposed a challenge" (1975, 90).

Environmental determinism can be detected in much of the above works, many of which also have a strong Darwinist or evolutionary bent, applying words such as variation, adaptation and natural selection, normally associated with biology and ecology, to cultural life. This cultural ecological approach to understanding humans and their environment (also sometimes labelled human behavioural ecology) uses ecology in the traditional sense. That is, as a branch of biology dealing with the interrelationships between organisms and their environment. Researchers working within a cultural ecological framework argue that such an approach need not apply only to the natural world, but to cultural life as well. Therefore societies are adapted to their environment. In this way, the characteristics of those societies can be explained in terms of such an adaptation (Johnson 2010).

This intellectual structure is largely derived from economics and therefore based on models taken from modern capitalist societies. This can be well seen in the statement from Halstead and O'Shea (1989) that diversification of diets as a response to environmental variability "represent a passive form of banking or savings" (1989, 4). Such an approach, Thomas has pointed out, sees human behaviour “in terms of adaptive responses to environmental pressures” (Thomas 1988, 59). The Mesolithic period, therefore, becomes a “cybernetic wasteland” (1988, 64; 1991). Or, to put it another way, leaves us with a view of a person as a “plastic, malleable cultural dope incapable of altering the conditions of his or her existence and always subject to the vagaries of external non-social forces beyond mediation or any realistic form of active intervention” (Shanks and Tilley 1987a, 56; 1987b).

Similarly, the deterministic models are largely framed within the ideas of optimal foraging theory, which also derive from modern economics. Optimal foraging theory is used to predict rational forager behaviour based on the balance of energy intake from resources and expenditure due to procurement of those resources. The basis for such an approach assumes that hunter gatherers will always react in the most economically efficient way in relation to external factors. These may include, for example, climate change or sea-level rise. Any divergence must, therefore, be culturally induced. In this way, it is suggested that behaviour can be studied scientifically, and nature separated from culture (Chapter 2).

Mesolithic research now is a far cry from the simple notion of a period of time, and many new and innovative studies are available (*eg* Conneller 2004; papers in Conneller 2000; Conneller and Warren 2006; Milner and Woodman 2005b; Bevan and Moore 2003). However, despite debate on the subject (*eg* Mithen 1990; 1991; Thomas 1988; 1991), environmental determinism is still firmly rooted.

Earlier conceptions still infuse much of the literature (*eg* the use of Jochim's optimal foraging model in Fitch 2011), and studies of subsistence patterns have "barely changed over the last 50 years" (Milner 2006, 63). There has been remarkably little advancement of the subject in anything other than in economic or environmental terms. This may be due to the nature of Mesolithic signatures, which largely comprise lithic assemblages and environmental remains.

This has been further hindered by the very fact, as described above, that the Mesolithic period has been defined as an economic adaptation to a particular environment. Chatterton (2005) has pointed out that this has, in turn, attracted scholars mostly interested in studying non-social matters, allowing others interested in ideologies, beliefs and worldviews to focus on the Neolithic and later periods (see also Strassburg's 2003 polemic).

1.4 This study

This thesis makes a case for a reorientation in discussions of Mesolithic sea-level rise and environmental change to incorporate the social as well as the economic and technological aspects. It sets out to understand the social aspects of sea-level rise in the Mesolithic period; that is, the experience of environmental change that resulted in the inundation of the environment and the ultimate loss of land. There has previously been no serious attempt to socialise rising sea levels in the Mesolithic.

In undertaking this work, it was felt that what was needed was not new data, but new interpretations and ways of reading the evidence. Data collection need not be the first stage of sea-level research; indeed, the formulation of primary questions is perhaps a better starting point. Therefore, this thesis does not focus on individual detailed case-studies, but ideas, and of necessity is wide-ranging, drawing on recent climate change discussions.

It is also necessarily multidisciplinary, using evidence from physical geography to discuss the effects of sea-level rise (from both Britain and the Continent), tying this in with evidence from biology and human geography. It also makes use of the cognitive science and philosophical literature, in order to understand perceptions of the environment and change. The sources it draws on are archaeological (although not all strictly Mesolithic), anthropological and ethnographic (although not all hunter gatherer).

The anthropological and ethnographic record is used to discuss how contemporary groups are responding to sea-level rise, and reveals the many different possible responses to it. It is acknowledged that modern hunter gatherers are not fossils of the past, unaltered and ahistorical (Gosden 1999; Jordan 2006). As Mithen states, it would be "foolish to forget that we are seeing modern and not 'Stone Age' society" (1990, 52). Ethnographic analogy can, however, be a useful device to gain an understanding of the possibilities of human behaviour, and certainly the complexity and variability of it. It is in this way that it is used here.

Following this introductory chapter, Chapter 2 develops from the above discussion on environmental determinism. It suggests that previous discussions have frequently seen the environment in economic terms; that is as a resource for Mesolithic people to use. This, it is suggested, removes much of the complexities and richness of life. Instead, this thesis will adopt a different approach that reconnects our notions of nature and culture. It therefore avoids an over-dependence on understanding the environment as an external force that had to be contended with or controlled. But at the same time, it does not lose sight of the importance of physical changes to the environment. This way, we can understand that the Mesolithic hunter fisher gatherers were immersed from the start in their changing environment, actively engaging and dwelling in it. The landscape was not simply a backdrop against which life occurred, but part of the hunter fisher gatherer's world, and people had an intimate relationship with it and everything within it. Sea-level rise and the associated effects can best be seen as an indivisible part of the landscape; not something external to it, acting upon it, and not something to be controlled or a problem to be overcome. Coastal zones are by their very nature dynamic and ever-changing; it is this fact that makes them so productive and draws people to them in the first place.

Chapter 3 explores the detail of relative sea-level rise during the early Holocene, looking at the drivers of change. The two main processes are eustatic sea-level rise and isostatic readjustment. Other complicating processes include the forebulge effect, and hydro-isostasy. Various complexities and uncertainties are considered, such as the amount, timing and variation of these events, and the weight and thickness of ice sheets. It is suggested that existing models do not capture the full dynamic response of sea-level changes, and that the non-linear nature of it makes prediction difficult. This highlights a central issue for the thesis: the large-scale models (which is the scale sea-level rise is studied – for example Shennan *et al*.

2000) are not conducive to discussions of the human experience of change. Alternatively, if we focus on short-term, local-scale dynamic changes, such a study becomes a realistic possibility.

Chapter 4 brings together much of the emerging information from the North Sea and Channel/Manche area, providing a characterisation of the landscape, identifying key topographical features and drainage patterns. For the purposes of this thesis the area is divided into three geographical areas. This comprises the upper southern North Sea, the lower part of the southern North Sea, and the eastern Channel/Manche area. Broadly speaking, the submerged area can be described as a wet, low-lying, flat and fluvially dominated landscape, although chalk outcrops will have provided some higher relief. The case is made that these wetlands, far from being peripheral, will have formed a focus for activity in the Mesolithic period.

Chapter 5 discusses the detail of the effects of sea-level rise. It includes descriptions of how rising sea levels affect the whole environment, from the smallest of algae, to fish nurseries, to woodlands, and of course its human inhabitants. This includes the effect of the loss of land on people; that is to say, the loss of 'place'.

Chapter 6 examines the possible responses of groups to the changes described. These responses may have included flexibility, diversification, and an intensification of ritual practices, as well as movement and migration away from the submerging areas. The role of information in increasing resilience is discussed and it is argued that by actively engaging with their surroundings and monitoring the environment, people could build an accumulated knowledge of their changing environment. It is finally suggested that sea-level rise and the associated changes could have also bought about certain opportunities. We so frequently associate environmental change with disaster that it is easy to forget that positive results can arise.

Finally, Chapter 7 reflects on the loss of the landscape in later periods and concludes the thesis, pulling the foregoing chapters together and summarising the main findings. Future directions for the study of this Mesolithic landscape are also sign-posted. The thesis ends on a short narrative account of how the post-inundation landscape may have been understood by some people in the Neolithic period.

As noted above, 'Doggerland' was a term coined by Coles (1998) in honour of Clement Reid's suggestion that the area was once dominated by the 'Dogger hills' (now the Dogger Bank). Vere Gordon Childe had, however, already referred to the area as 'Northsealand' in his later books (the sixth edition of *The dawn of European civilization*, 1957, 37, 47; and *The prehistory of European society*, 1958, 27–30), a point that Coles did not acknowledge (see also Saville 2009). Most authors now refer to it as Doggerland, although Strassburg (2000, 95) used 'North Sea land', and Momber *et al*. (2011, 160) referred to it as both Doggerland and Northsealand. The 3D seismic reflection data described above has, however, shown that the Dogger Bank (as with other sand banks) is largely the result of recent submarine deposition (Chapter 4) and it would, therefore, not necessarily have been an obvious topographical feature during the early Holocene (Gaffney *et al*. 2009, 68; *contra* Van de Noort 2011a, 144; Peeters *et al*. 2009). This, to my mind at least, rather undermines the name

Doggerland. Although Doggerland does have an appeal, and has certainly become firmly ensconced in the public's collective mind, in this thesis Northsealand has been favoured, or, occasionally, the North Sea plain or lowlands. The Channel/Manche area is included within this name too.

Chapter 2

The place of nature and the nature of place

"It is important to realize that man is an animal, but it is even more important to realize that the essence of his unique nature lies precisely in those characteristics that are not shared with any other animal. His place in nature and its supreme significance to man are not defined by his animality but by his humanity" (George Gaylord Simpson, 1949, 284).

2.1 Introduction

It is worth setting out here the theoretical background underpinning this thesis. In Chapter 1 the nature and development of Mesolithic studies was discussed, highlighting the frustratingly stubborn dominance of environmentally determined models. Developing on from this, this chapter will focus on the way humans engage with their surroundings, both practically and imaginatively. Clearly, human-environment relations are an important part of understanding the effect that changing environments would have had.

Conventionally in Western thought nature and culture have been viewed as separate. However, following writers such as Bateson (1973; 1979), Gibson (1979) and Ingold (2000; 2011), it is suggested here that categories such as these are unhelpful and should be reconnected. This approach provides an alternative to much of the existing consideration of early Holocene sea-level rise, which tends to be rather one-dimensional, framing nature as an external force to be dealt with. In this regard too, notions of 'place' will also be set out, since this will be picked up again in later chapters through an analysis of how the loss of land as a result of sea-level rise affected people's sense of place.

2.2 The place of nature

The nature/culture duality can be traced back through Locke, Hobbes, Rousseau and their seventeenth and eighteenth century Enlightenment contemporaries to the emergence of anthropocentric intersubjectivity (Thomas 2004, chapter 8). A dichotomy between the mind and body can similarly be traced through this intellectual lineage, owing much to Descartes: "accordingly this 'I' – that is, the mind by which I am what I am – is entirely distinct from the body … and would not fail to be whatever it is even if the body did not exist" (Descartes 1637, 54).

Culture was seen as something that emerged from a state of nature, as a separate self-contained entity, disembedded from its physical surroundings (Thomas 2004, 82–4). Materials could therefore be taken out of nature and transformed into culture. As Thomas puts it, "this had the effect of encouraging modern westerners to think of the world as a set of resources that lay at their disposal to consume as they wished" (2004, 83). Human progress could be measured by its ability to exploit the natural world. While philosophers may have largely abandoned this position, it still informs the major part of Western daily life, and through this process nature has come to be seen as an 'other', as something to be subdued and controlled.

The emergence of culture was seen as a linear process, advancing over time from a state of nature towards civilisation (Thomas 2004). Highly mobile hunter gatherers were seen as closer to nature than, say, settled farmers. Similarly, nature was framed as timeless, whilst humanity was temporally variable (Thomas 2004). Therefore hunter gatherers were enduring, that is to say ahistoric, while later periods were dynamic and progressive. Archaeology could, in this way, trace the evolution of humanity out of nature, rising above it and bringing it under control through domestication. As set out by Clark and Piggott: “it is one of the main tasks of prehistory to trace the emergence of characteristics of a peculiarly human order, characteristics without which human society could hardly have risen” (Clark and Piggott 1965, 15). Present day hunter gatherers could then be framed as primitive relics of the past, still struggling to rise above nature.

Growing European contact with indigenous groups fostered this view. This led to nineteenth century accounts of hunter gatherers as if they were nature, no better than wild animals and unable to achieve mastery over their environments (Ingold 2000). Darwin’s account of the inhabitants of Tierra del Fuego, for example, describes his disgust at seeing such ‘savages’: “I could not have believed how wide was the difference, between savage and civilized man. It is greater than between a wild and domesticated animal, in as much as in man there is a greater power of improvement” (1839, 172). For Darwin they were “miserable creatures”, who slept “on the wet ground coiled up like animals” (1839, 178). Similarly, in 1869 an argument within the scientific community over the body of William Lanney, the last Tasmanian Aborigine, was fuelled by a belief that he was the “last living link between man and ape” (Brody 2001, 278). Similar themes can be found in descriptions by Dutch explorers of the Bushmen of the Cape coast, South Africa (Tooke 1908), or of Australian Aborigines (Dampier 1697).

These views, whilst not necessarily framed in such terms now, have influenced and infused twentieth century anthropological, and in turn archaeological, studies of hunter gatherers (Chapter 1). Indeed, Lubbock explicitly used the Tierra del Fuego Indians as an analogy for inhabitants of the Ertebølle culture (Lubbock 1913, 189). Salick and Byg (2007, 4) point out that, "the IPCC [Intergovernmental Panel on Climate Change] II report summary on climate change impacts makes only scarce mention of indigenous peoples, and then only … merely as helpless victims of changes beyond their control". This can be compared to archaeological discourses on sea-level rise that either do not mention how people may have perceived or responded to sea-level rise, or describe hunter gatherers as passive victims of their environment.

This 'struggle against nature' approach can be detected in Gaffney *et al*.'s description of the inundation of the North Sea as having been "devastating for the Mesolithic populations" with "the stress of the indigenous populations [being] beyond our experience" (2007, 8); "tremendous environmental change forms the backdrop to cultural events throughout this period" (2007, 105). On the other hand, and yet similarly framed within a nature-culture dichotomy, Coles sees the expanding estuarine habitat as compensation for the loss of land, suggesting that "neither land loss nor the spread of thicker forest cover necessarily stressed Doggerland's inhabitants in the earlier part of the Mesolithic" (Coles 1998, 76). The latter has echoes of the nineteenth century views of hunter gatherers as being closer, or even a part of, nature, while the former sees the environment as a ‘backdrop’, something that endures behind human actions and affairs. These embody the above-discussed twin ideas of hunter gatherers as powerless before the forces of nature, versus nature as a resource. With these two approaches (Gaffney *et al*. 2007 and Coles 1998) we are at the opposing ends of a sliding scale, both of which view sea-level rise as something that is externally imposed on society; something outside of culture. Furthermore, we are left with a sense that all people are equally affected by sea-level rise.

To take a more recent example, Fitch (2011) explicitly uses the optimal foraging model in his thesis, applying Jochim’s method to provide a model of change during the Mesolithic in a region of the southern North Sea as a result of sea-level rise. Through this he argues: “the most likely driving force upon cultural evolution during the period is environmental change” (2011, 58), and that the “Mesolithic period … is best determined at the environmental time scale” (2011, 126).

In a similar way and strangely out of tune with the rest of the book, Hodder (2012), discussing climate change at the beginning of the Holocene, also sees the environment as a separate entity: “even if this effect was varied in different parts of the globe, and even if we do not understand the effects adequately, this climate change, unlike our own, was independent of humans” (Hodder, 2012, 93). He suggests that the environment had “the dominant hand” (2012, 94).

These are just a few of the examples of the types of approaches to sea-level rise and climate change in archaeology, but they neatly embody the contradiction between, on the one hand, free choice and, on the other, environmental determinism. They exemplify the tension between ideas of nature as a resource to be exploited by people and views of hunter gatherers as those closest to nature, subject to its force. They also do not ground people within their environment.

The dichotomy between nature and culture is firmly rooted in Mesolithic studies and archaeology more generally. By painting humans as essentially separate from their environment we end up seeing them as aloof, with the sense that Mesolithic people gazed on at the environment as if they were looking at a painting of a landscape (Bender 1999). By reducing people to mere spectators, they were not responsible for the events they witnessed within the environment. The environment becomes static and objectified; a container of resources to be dipped into as and when necessary, and a force that drives them away when it turns against them.

By studying the environment as something independent of and separate from humans, it is set up as a series of physical constraints. And in this way it is seen as ahistorical, something that has endured behind human affairs; a backdrop to human actions. Nature, in short, is understood as external and timeless, and people become helpless "victims of externally-imposed circumstances" (Thomas 1988, 61). Environments, however, like humans, are fundamentally dynamic, and they are historic too; that is to say, they are packed with the past (see discussion of 'place' below). We learn about our world in and through others, through interaction and imitation (or as Johnson [2007, 51] puts it, through "body-based intersubjectivity"). Rarely do archaeological accounts reflect on how bodies connect in a corporeal, embodied sense to their environment. As Malafouris (2004) says, such a dichotomy “provides a view of human cognition so purified and detached from the world that it resembles a ‘brain in a vat’, a disembodied input-output device characterized by abstract, higher-level logical operations” (2004, 55).

There are, however, other ways of framing human-environment relations. Over the last half century or so, a number of authors have sought to demolish the artificial dichotomy of nature and culture and, similarly, body and mind. To take an example, in the 1960s anthropologist Gregory Bateson developed a concept of an ‘ecology of the mind’, which saw the mind as not so much a thing but a process; that is to say a living system (Bateson 1973). For Bateson the mind and ecology were situated in the *relations* between the brain and the surrounding environment, with no boundary between the mind on the inside and the world outside. In this way the interactions of a living organism with its environment were cognitive or mental interactions. Life and cognition are thus inseparably connected, and the world opens up in a process of revelation. Bateson maintained that changes resulted from both environmental constraints as well as free choice, while an organism’s disposition could also limit the adaptive potential (Bateson 1979). In this way, organisms can both consciously adapt and transform, while also being limited by the characteristics of its body, which is itself partially inherited and partially developed and extended through particular environmental conditionings.

Similarly, ecological psychology, as laid out originally by Gibson and his studies of visual perception (1979), starts with the notion that perception of the everyday world is not something that occurs in the mind but with the whole body (mind and body) moving in its environment. Perception then is a mode of action; it occurs during an active engagement with the environment. Perception is accessed directly, and not a cognitive reconstruction, and is distinct from the laws of physics, time or space (Gibson 1979; Ingold 2000; Knappett 2004). Perception itself can also be cultural, that is that there are ways of perceiving. Furthermore, the perceptions of objects and environments, even familiar ones, are being forever changed according to the perceiver's viewpoint. That is, that from any one position at any one time, some things are hidden, others are revealed.

For Gibson, the environment, which consists of substances, mediums and surfaces (surfaces being where substance and medium meet), affords certain things. Gibson's theory of affordances acknowledges how we pick up information appropriate to our needs directly from the environment, and how the environment and objects within it offer potentialities for particular sets of actions. As he states:

> "an affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behaviour. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer" (Gibson 1979, 129).

Gibson's ecological psychology links mind and body and embeds perception as a practical element in an individual's life. Perception in these terms is, therefore, a continuous and active attention to the environment. In this way, we can see that bodies have a direct dialogue with the physical environment. They are in relation to it, and perceiving organisms (human or otherwise) should be treated not as passive recipients but active agents.

There is some degree of overlap between these ideas and those derived from the phenomenological tradition, namely from Heidegger and Merleau-Ponty. Phenomenology discusses an individual as a being-in-the-world; that is someone situated within their environment. The world, in the phenomenological view, is continually coming-into-being just as the perceiver is coming-into-being with it (Heidegger 1971; 1962). Inspired by Jacob von Uexküll's (1957) notion of an *umwelt*, Heidegger proposes that animals lack a sense of their environment as a surrounding world (1971, 43). For Merleau-Ponty too, we (that is a body in its totality) are immersed in our environment, acknowledging a dynamic between perceiver and perceived (Merleau-Ponty 1962).

Phenomenology shifts the emphasis of perception by focusing on what is immediately felt and experienced by human beings; that is to say the subjective experience. Phenomenological approaches are therefore more interested in the experience of 'knowing' rather than simply 'knowing about'. It is through inhabiting the world, being there, that the environment is perceived and becomes meaningful, and not through a reconstruction of it in the mind.

Influenced by these approaches, Ingold has sought to regain an 'ecology of life' or 'sentient ecology', breaking down the dichotomy of nature and culture by combining organism and environment. He has argued for an ecological perspective in which hunter gatherers dwell in the landscape. That is, that they are firmly situated within it; they are part of the environment and engage with it, and not external to it. Organism and environment, rather than separate, are co-emergent properties of life (2000; 2011). In this way, it is the *interactions* between Mesolithic communities and sea-level rise that needs to be understood.

Key to Ingold's concepts is the idea that experience of an environment and the movements within it provides knowledge of it. Rather than mediating between mind and nature (since, as he points out, these are not separated in the first place) it is intrinsic to the process of living. This, he describes, as 'dwelling' in the world; a perspective derived from Heidegger (1971). Ingold introduced the concept of the taskscape or taskspace to allow discussion of dwelling in the land.

Further, Ingold's influential writing has done much to break down assumptions of optimal foraging theory and hunter gatherers. In particular arguing that human behaviour is complex and rarely focussed solely on expediency or resource needs. Novices learn to perceive the world through a 'sensory education' formed through a series of clues derived through engagement with the environment. Stories and songs help shape perception of the world and inform motives.

In this way he argues that we cannot simply overlay our Western views of economics onto hunter gatherers, who perceive the environment very differently. Hunter gatherer lives are rich with symbolism. These are points also discussed by Tilley (1994) who has argued that the Mesolithic landscape would not have been perceived in purely economic terms, but would have been loaded with social and ideological texture.

Following Ingold's argument, therefore, we can understand ourselves as situated within the developing environment. Skills and knowledge are acquired through a relationship with the environment, a relationship that is generated and fostered through an engagement with and movement through it. Once again, engagement emerges as essential to our perception of the environment. As Bender has pointed out, "landscapes are created by people – through their experience and engagement with the world around them" (1993, 1).

The work discussed above takes ecology as a totality – 'a dynamic organism/environment'; what Bateson refers to as an 'ecology of the mind' and Ingold an 'ecology of life'. Similarly, we need to reconceptualise our understanding of the Mesolithic worldview as one that fundamentally unites nature and culture. There can be no dichotomy between social and ecological relations – rather they are part and parcel of the same thing, and separating them into categories is unhelpful. In this way, cognition and experience are not things that happen in the head, but in relation to the world around them. People and the environment emerge through the interactions between them. It is not enough to have an objective measurement of sea-level rise. Rather there needs to be a greater understanding of the intersections between people and sea-level rise – its affordances in Gibson's terminology.

A similar theme emerges from the literature on embodiment, which has grown out of the work of philosophers from the phenomenological tradition as well as emerging cognitive sciences over the last three or so decades. The notion of embodiment argues (with strong empirical evidence) that the mind/body and human/environment dualisms are a fiction and in reality parts of one organic process, and that every aspect of the human being is grounded in an engagement with the environment (for example Johnson 2007; Lakoff and Johnson 1999; Varela and Shear 1999; Damasio 1999; 2003; 2012). That is to say, we are not locked up in a world of our mind and it is not simply a process of computation in the head. Instead we make sense of the world through our situation in, and interaction with, the environment. As philosopher Alva Noë puts it "you are not your brain" (2009, xiii). We are fundamentally embodied and involved with our environment; we are in it and of it. "It is the world itself, all around, that fixes the nature of conscious experience" (Noë 2009, 142).

Full human experience cannot be broken down to a series of physical, chemical or neurological process in the brain. Thinking and finding our way around cannot be confined to the skull (Noë 2009), and people are not self-contained or autonomous, making decisions on purely mechanistic terms. They are, instead, environmentally situated.

Furthermore, emotional responses (feelings and passions such as joy, fear, honour, pride, or a jealous rage) play a central role in understandings, motivations and bodily interactions with the world (Damasio 1999; 2003; 2012; Johnson 2007; also Mithen 1991 and Gosden 2004 for a discussion of this within the archaeological sphere).

Emotions affect the way people engage, monitor and appraise the world around them; they "enter into our more conscious deliberations about how we should respond to our situation" (Johnson 2007, 61; Damasio 2003); they emerge from interactions with the world. Thus any response to sea-level rise is an emotional response as much as anything else. Emotions are primal driving forces that move people to action. Any account of past behaviour based on mechanistic judgement alone, such as optimal foraging models, clearly misses a fundamental part of what it is to be human; the way people engage and interact with their surroundings. “Real logic” as Johnson (2007, 102) puts it “is embodied – spatial, corporeal, incarnate”.

Descriptions of environmental change as a ‘backdrop’ miss the point, for nothing ever exists separately from its background – things are entangled with their contexts. “It is a totality of involvements, a network of relationships within which things are enmeshed” (Thomas 2004, 185); “the connections are very heterogeneous such that human and thing, subject and object, culture and nature are all thoroughly intermingled” (Hodder 2012, 48).

In this way, Mesolithic communities would not have understood their environment as an external world of nature, with sea-level rise as something that had to be dealt with. They would have related to their surroundings just as they would with other humans. And these surroundings may include flora, fauna and physical entities such as the sea, all of which they were familiar with (and some of which may have had similar status to other humans). Their world was an integrated whole.

Archaeological evidence for this may come from Mesolithic cemeteries in southern Scandinavia, where humans and dogs appear to have been treated in death in similar ways, *ie* similar burials and in some instances receiving the same grave goods (Larsson 1990a). This suggests that there was no attempt to “distinguish between the human and animal kingdoms" (Bradley 2004, 110; 1997), and that "other non-human species could have held a special position in the societies" (Larsson 2007, 603).

Similarly, human remains deposited alongside animal remains in some midden sites have led Chatterton to remark: "these deposits suggest that the remains of all living beings were discarded in a similar fashion" (Chatterton 2006, 115). Comparable points that draw the human and animal kingdoms together have been made by Conneller (2003; 2004) and Cummings (2003).

Conneller (2006, 161) has warned against generalising the nature of human and non-human relations in the Mesolithic, and difference will have existed across time and space. However, the point here is to highlight that Mesolithic people were not disembodied minds engaging with other minds, but entire persons engaging with other people, animals and the multitude of elements of their environment. This could have also included geophysical phenomena, such as sea-level rise and changing ecosystems. They were beings *in* a world, not minds representing it.

Furthermore, environment is a subjective term and is constituted in relation to the person perceiving it. As Gibson (1979, 8) points out – there is no environment without an organism to perceive it. Perceptions change depending on viewpoint, experience, what is important to the perceiver, and the mood of the perceiver (see Thomas 2004, 188 for this latter point). For this reason too the environment undergoes change in relation to the perceiver. The environment also does not reveal itself as a final form to the perceiver, but is a process, constantly unfolding and developing, just as life does.

This approach is an important alternative to traditional conceptions of Mesolithic ‘victims’ of sea-level change; of legions of noble but head-bowed Mesolithic men, women and children, trudging away from their flooded homes (an exaggeration perhaps but the point remains). Instead, it is a holistic approach drawing the social, the economic, and the environmental together.

In addition, this approach can be distinguished from other Mesolithic studies, which are often articulated as if through a rather static lens, by viewing the world as one of continuous change, transition and flux. In fact, change and impermanence are at the heart of this approach. The environment is not immutable, but constantly variable, forever changing and moving, eroding and depositing. This is particularly so with coastal areas, especially during periods of sea-level rise. Like the social world, landscapes are intrinsically temporary (Ingold 1993; 2000). There is no equilibrium and they are perhaps better understood as “persistence under change” (Gibson 1979, 13).

To those engaging with the coastal environment, change and dynamism are part and parcel of what it is. By actively engaging with the environment people were also immersed in the changes that took place. Indeed the changes were an intimate part of their day-to-day lives, and people’s relationship with the world was a dynamic one.

2.3 The nature of place

This discussion of nature brings us onto another important and related topic – the nature of place. Place can be defined in many ways but is frequently conceived as either a physical location with fixed co-ordinates, or, at the other end of the spectrum, as a purely abstract symbolic construct (mirroring the dichotomy of nature/culture or mind/body). Both interpretations, however, can lead to an understanding of it as simply a backdrop to activity.

The latter interpretation, in particular, implies that place can be undone socially and recreated elsewhere irrespective of the physical place. If this were the case, the drowning of places in the Northsealand would not be a significant problem since people could just move away from the inundating areas with minimal sense of loss. For example, Coles' suggestion that: "the extending coastline, the expanding estuarine habitat and the increasing diversity of inland resources may have been sufficient to compensate for overall land loss and to *soak up* most of the potential migration in the face of rising sea levels" (Coles 1998, 76, my emphasis), implies that people moved easily from one place to another with little problem re-creating it in new areas as land was lost and as resources dictated.

However, as discussed above, it is important to appreciate that the landscape is not simply a backdrop against which life occurs. It is the world as it is known to those who inhabit it and they therefore have an intimate relationship with it and everything within it (*eg* Cosgrove 1984; Olwig 1993; 1996; Bender 1993; Tilley 1994; Hirsch and O'Hanlon 1995; Ucko and Layton 1999; Edmonds 1997; Ingold 2000; 2011; Thomas 2001;

McFadyen 2006). When places are removed, in this case as a result of inundation through sea-level rise, so do people's sense of place in the world (Chapter 5).

Human lives are enmeshed with place, and people are embodied and located. Place is neither physical nor purely symbolic but arises from interaction with environment. Through these interactions, memories, narratives and identities are formed. As Malpas states: "place is primary because it is the experiential fact of our existence" (Malpas 1999, 32). This is similar to Lefebvre's thirdspace – the practiced and lived space rather than place being simply either material (conceived) or mental (perceived) (Lefebvre 1991).

Place is highly evocative; it can remind one of an earlier event, a feeling, a person, a loved one, a death, or an experience from childhood. Many authors have drawn attention to the fact that place is closely tied to memory; or to put it the other way: memory is closely tied to place (*eg* Bradley 2002; Ingold 2000; Malpas 1999; Gosden and Lock 1998; Tilley 1994; Edmonds 1997). Every woodland glade, coppiced tree, or axe mark, and every lithic scatter or decaying house platform tells of a history – both personal and communal; a story of actions past and of lives lived in that place. Environments are historic, that is that they carry with them the evidence for past changes.

As Rumsey says for Australian Aboriginal groups, "the country stores memories that were inscribed there by human agents" (Rumsey 1994, 127; Smith 1999; Morphy 1991). Or, to take a different example, as Basso (1996) claims for the Western Apache of the US Southwest "… because places are visually unique (a fact marked and affirmed by their possession of separate names) they serve as excellent vehicles for recalling useful knowledge" (1996, 134). In this way, features in the Western Apache landscape are descriptively named and tied to lifeways providing a sense of place and history. This is true of most hunter-gather groups (Kelly 2003), and can be seen, for example, from Saami culture (Broadbent and Edvinger 2011; Bradley 2000) and other northern Eurasian small-scale groups (papers in Jordan 2011), to Inuit groups. In the latter, the landscape is "given a set of complete human shapes – names and purposes and meanings" (Brody 2001, 35). Further case studies have been previously set out by Tilley (1994). In this way too there is no gap between the human and non-human realms, between culture and nature (also Cosgrove 1989; Meinig 1979).

Some groups do lack historical depth, for example the Siberian Iukagir have very few inter-generational place names or myths (Willerslev 2011). While people of the nomadic Evenkian culture of Northern Transbaikal carefully structure their settlements in the same way each time they move, so that "we never move – it's the world that moves" (Grøn and Kuznetsov 2003, 217). But even these communities are not 'ahistorical', and attach immediate events and people's names to places. Places still have a meaning.

It is not just the visual perception of place that makes it an important source of memory and knowledge either. It is the full range of senses – sound, smell, feel, even the taste. We attach feeling to the place – of varying emotional strength – based on these memories. Such memories provide a sense of the past; a past that is tied to a particular place (Tilley 1994). It provides a sense of an individual past, of embodied actions – it forms a personal biography. Similarly, place can also provide a communal history too, since events, and memories of the events, are shared. Such communal histories often interlace with myths – myths, like histories, that are inscribed across the landscape and located in particular places (Rumsey 1994; Gosden and Lock 1998).

Communal memories such as these can provide a sense of cultural identity, and indeed identities are closely linked with particular locations. When one thinks of a community an archetypal image of that group's landscape is very likely to come to mind. As Malpas asserts, it is often difficult to tell the story of a culture without also incorporating the story of their physical land (Malpas 1999, 187). The environment provides social identity.

Individual identities are also place-bound – in modern times a search for identity is often a search for place. We are involved – that is to say, entangled – with our places. Noë puts this:

> "we are *of* them … When we transplant ourselves as immigrants get transplanted, when we move from one town to another or one country to another, we suffer injury, however subtly or grotesquely or even painlessly, and so we are altered. ... no matter how charming you may be, how wonderful a raconteur, if you find yourself in a strange land where a strange language is spoken, you can't tell a good story – that is, you can't be what you are. You yourself are changed" (2009, 69).

Identity is embedded in the world, with the surrounding environment – the distinctive 'texture' (to borrow from Evans 2003) of the land. And one's life can be defined by a region – it embodies who we are (Malpas 1999). When landscapes changed in the Mesolithic period (Chapter 5) as a result of sea-level rise, and when places were inundated as thresholds were crossed and people moved to drier areas (Chapter 6), both individual's and communities' sense of being would have changed.

Place embodies both space and time, and by showing the links between living people and past generations it can be used as an expression of kinship – as a way of showing ancestral ties to a piece of land (Tilley 1994; Thomas 2001). It is also worth remembering that place can also be used to appropriate the past just as much as represent it. Places can have complex histories – histories that are articulated with respect to particular people and locations, and can mean different things to different people. For instance, places do not necessarily produce happy memories; certain places can remind one of repression and abuse. They can pull painful memories to the fore, or be oppressive (particularly across gender, age, or ethnic lines). Places can also be acts of exclusion, such as where people spend critical periods of their life, or indeed places of resistance. Places can have different meaning, some with spiritual potency, some where people died, or where particular hunting events occurred or other personal experiences. "The landscape is inscribed with the lives of all who have dwelt therein" (Ingold 2000, 54). It is a congelation of past activity, human predecessors as well as ancestral beings.

Through the memory of place, and an understanding of its past, a narrative can develop – it can provide a sense of the story. Like memories, these narratives may be personal, historic, mythic or all of these things, and are marked out by actions – pathways, axe marks, flint scatters. The landscape represents a storehouse of memories and ideas, and narratives are written into it. Relationships and specific attributions can be attached to physical features, so that places can be named or imbued with symbolism or myth; structuring memory and providing identity. These stories can define cultures. Actions in a place are therefore embedded in a narrative and these narratives can be nested within broader narratives. Like memories, narratives are always multiple – there are different ways of understanding a place, different ways of ordering memory. There is always more than one story.

Places do not exist in the minds of the people to be mapped onto the landscape, and the environment does not form an external background. In this way, it is unlikely that Mesolithic people could have moved their place to drier areas without consequence. People live within the landscape and through interactions and the process of living an embodied entanglement develops and enters a person's constitution – their very make-up. As discussed above, people are environmentally situated, that is to say wrapped up in place.

This of course is not to suggest that the environment was a succession of places, but a flow. Places are not static, but are connected, and these connections are made by movement through them – that is by an active engagement with the environment. It is through such an active engagement that the complexity of place can be understood. Indeed some places may only be disclosed through movement. Paths and trails are worn by the regular act of walking, and once one is present it attracts further travel along them. Through this frequent, habitual travel along them, paths become part of the people using them; a reflection of the movements and repeated actions (Tilley 1994).

Moving within the landscape is also an essential task for gathering a detailed knowledge of the local environment. As set out above, people learn about their environment by actively engaging with it – that is, they learn to read the land, the subtle signs and indicators in the ground that can announce the presence of certain birds and animals. A relationship with place develops. Knowledge is accumulated; it "grows through a lifetime's experience of living in a place and moving in its environs" (Ingold and Kurtilla 2000, 187).

Part of this knowledge is phenology, the understanding of cyclic and seasonal phenomena: the knowledge of when flowers bud, fruits ripen, or when birds or animals migrate (see Chapter 6 for more on phenology). Phenological data are about observation, experience and interpretation, and are based on long-term knowledge of a specific location. Movement provides a sense of connection with place and nature and affords the opportunity to have a detailed knowledge and sensitivity to it. An understanding of place comes through activity, and actions establish a relationship with specific features – features that themselves have agency.

Places are formed by people living their everyday lives through a repetition of practices. This has been discussed by Henri Lefebvre who talks of ‘rhythmanalysis’ – the social practices (the actions) that make up rhythms – whether they are daily, monthly, or yearly (Lefebvre 2004). That is to say, the patterns or life – the rhythms – form places and our sense of them. This may be particularly so for people occupying places near the sea, which has a perceptible and clearly predictable rhythm to it (Sturt 2006; and see Chapter 4). Similarly, Wendy James has argued that places embody the movements that create them; they are created out of the repetition of activity (James 2003).

2.4 Chapter summary

Understandings of the world around us continue to be influenced by the linked notions of nature/culture and mind/body as separate entities. As well as by the idea that we are independent beings, who can exist separate from our context and create *our* place somewhere new as external forces dictate. From this perspective, the environment is there to serve our needs and purposes, and humans are considered central with the environment as a backdrop, albeit an influential one. In this way also, place can be picked up and recreated elsewhere.

However, in this chapter humans and the environment (including our notions of place) have been drawn under a single conception, emphasising the dynamic relationships that exist between them. It therefore suggests that Mesolithic people were constantly evolving beings within a dynamic environment, with countless choices and the potential for transformation. This has reoriented discussions away from Mesolithic groups ‘doing’ things in the environment, to the dynamic experiencing of living in the world as part of a profoundly inter-related network of beings. In these terms, the notion of the word 'nature' is as odd and unfounded as the word 'culture'. This approach integrates human agency within environmental systems. Environmental deterministic models miss much, but the environment is still important ("you cannot grow maize in the arctic or build igloos in the jungle" [Evans 2003, 94]).

Guattari puts this as: "nature cannot be separated from culture; in order to comprehend the interactions between ecosystems, the mechanosphere and the social and individual Universes of reference, we must learn to think 'transversally'" (Guattari 2000, 29). More recently Morton has argued that in order to have ecology we have to let go of 'nature' altogether (2007; 2010). Similarly, and within archaeology, Van de Noort has called for a greater understanding of the connection between people and their environment (2011b). And that "nature is not wholly externalised from society, but is not understood to be wholly internalised either. Humanity's relationship with the environment we live in is essentially a hybrid one, with influences, impacts, interdependencies, and interrelationships varying from place to place, from time to time, and from situation to situation" (Van de Noort 2013, 728). This is also the approach adopted by Åkerlund in her discussion of responses to shore displacement in Sweden (1996).

This chapter has highlighted that change is an intrinsic aspect of any environment, and that Mesolithic communities would have had a fundamental awareness through a sensorial engagement of these changes, and acted accordingly. As well as this, notions of place have been discussed, the importance of which has been recognised for some time now in the Mesolithic period (Tilley 1994; Barton *et al*. 1995; Pollard 2000; Cummings 2003; Conneller 2005). Sites such as the Mesolithic buildings at East Barns (Gooder 2007), Mount Sandel (Woodman 1985; Bayliss and Woodman 2009), and Howick, have demonstrated “a long-term attachment to place” (Waddington 2007a, 110). Further, Simpson (2003) has suggested that different types of materials used for body adornments (*eg* beads) in the Mesolithic period may reflect a concern with a sense of place (principally the coast – Chapter 6).

The Northsealand landscape, as with any other during the Mesolithic period, would have been named and retained social significance with stories attached to it. It is therefore not something that, as land was being submerged, could have easily been recreated elsewhere. It formed part of the fabric of peoples’ being. These understandings set up and flow through the subsequent chapters.

Chapter 3

Shaping the world with ice and sea

"Who bidd'st the mighty ocean deep
Its appointed limits keep"
William Whiting 'Eternal father strong to save', 1860.

3.1 Introduction

There can be no doubt that the most radical changes to the landscape of northern Europe over the last 10,000 years result from sea-level rise. As ice sheets decayed at the end of the last Ice Age, sea-levels rose dramatically, engulfing vast tracts of land. However, precisely defining sea-levels, or even what we mean by the term sea-level, is notoriously difficult.

This chapter takes account of the processes that occurred in the early Holocene which led to the rapid rise in sea-level. The variations, uncertainties and problems of sea-level rise are highlighted, suggesting that the smoothed and homogenised nature of sea-level curves is not, on the whole, conducive to the study of human perceptions of change. The different scales of sea-level change are also emphasised. The importance of thresholds and tipping points in producing events that would have been perceptible, and perhaps dramatically so, are underlined.

3.2 Deglaciation and sea-level rise

Although the Last Glacial Maximum (LGM) is traditionally given as 21,000 years ago, recent work (Clark *et al*. 2012) has shown that the British-Irish ice sheet was actually at its greatest extent around 27,000 years ago. The exact limits of the British-Irish ice sheet have been debated over the last few decades, with Jansen *et al*. (1979) and Ehlers and Wingfeld (1991) on the one hand suggesting that it linked with the Fennoscandian ice sheet. While Sejrup *et al*. (1987) on the other suggesting that they were separated by a corridor of land. However, the Clark *et al*. (2012) work has provided convincing evidence that the ice sheets linked and that the British-Irish ice sheet was of a much larger area than previously recognised. It extended from the Atlantic continental shelf edge on the southwestern side across the area that is now the North Sea to the North Atlantic continental shelf edge on the northeastern (Fig. 3.1). It, therefore, covered all of Scotland including the Shetland Islands, Wales, Ireland, and England north of the Midlands.

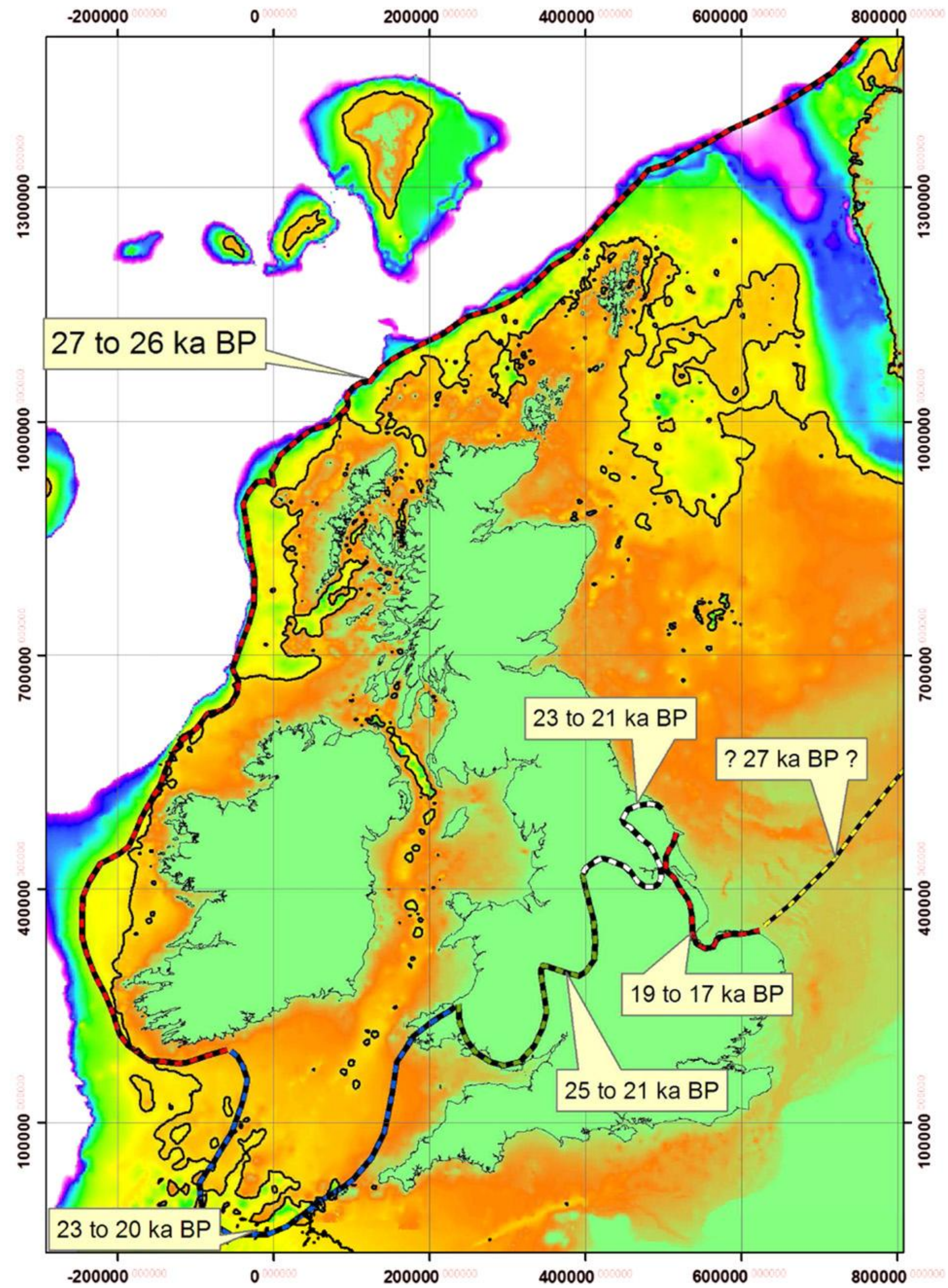


Fig. 3.1: The British-Irish ice sheet maximum limits against shelf bathymetry. (From Clark *et al*. 2012, 131).

As a result of a general warming trend of the global climate, ice sheets began to retreat. In one scenario put forward by Clark *et al*. (2012), the British-Irish ice sheet separated from the Fennoscandian 25,000 years ago. This suggests almost complete deglaciation of the North Sea by 23,000 years ago, although with an offshore lobe of ice re-advancing along the east coast of Britain 17,000 years ago before retreating again. Alternatively, and according to Clark *et al*. (2012) more contentiously, ice cover remained over the area that is now the North Sea for longer. The ice sheet continued to decay, separating the British from Irish ice sheet from around 16,000 years ago. Following a probable re-advance during the Younger Dryas (from around 10,950 cal BC) (Becker and Kromer 1993), it is likely that ice had wasted entirely from the North Sea area by around 9550 cal BC (Johnson *et al*. 1993; Clark *et al*. 2012).

During and following deglaciation, water previously locked in ice sheets (as well as glaciers, ice caps and permafrost) was redistributed throughout the ocean basins, with spatial variations largely based on gravitational potential. The influx of meltwater meant that sea-levels rose rapidly causing the North Sea to flood the low-lying plain to its south. At the same time, the Atlantic coastline advanced east along the Channel River to form the Channel/Manche. These two bodies of water eventually joined. The water thus flowing freely from the North Sea to the English Channel through the Dover gorge (now the Dover Strait), cutting Britain off from the continent, which once again became an island.

3.3 Sea-level change: A story of complexity

However, the mechanisms and processes of early Holocene sea-level rise are complex and controlled by an array of variables which operate over specific temporal and spatial scales. These can be divided into two broad categories: eustatic sea-level rise and isostatic readjustment, although the forebulge effect and hydro-isostasy also play an important part.

Eustatic sea-level rise is the global return of water to the ocean basins as a result of the deglaciation described above. Fairbanks (1989) estimates the water returned to the ocean basins will have produced a 120 m increase in mean sea-level (Lambeck *et al*. 2010 similarly put it at between 100 and 150 m). There was a rapid rise in the early Holocene at an average rate of one metre per century, with peak rates of several metres per century, after which (from about 4000 cal BC) the rate of rise slowed down (Church *et al*. 2010a). There are many localised variables that modify this rise in global water supply, and vertical changes at any given point are referred to as relative sea-level (RSL) (Shennan *et al*. 2012 discuss these terms).

One of the dominant processes controlling these variables is the isostatic readjustment of the Earth's surface following the decrease of ice-loads. Recent modelling has improved understanding of this process by taking into consideration the fact that mantle and lithospheric properties, such as viscosity and thickness, vary regionally (Mitrovica *et al*. 2010; Shennan *et al*. 2012). In Britain, patterns of crustal movements show uplift centred in northwest Scotland at the centre of the former ice sheet, a process that has continued to the present day, and subsidence in southeast England (Shennan 1989; Shennan *et al*. 2012). The 'hinge' line (zero isobase) between the two is often placed running from the Lleyn peninsula in northwest Wales, through the Wirral to the Tees estuary in northeast England. The degree of uplift and subsidence within the North Sea basin is, however, poorly understood. In northwest Europe, the pattern is related to rebound after the Fennoscandian ice retreat.

There are a number of other contributors to deformation and movement of the Earth's crust. Closely related to isostatic readjustment is the forebulge effect. This is the flexing of the lithosphere at the ice margin to produce an upward bulge. As the ice melted the bulge would have levelled out again. Forebulge is constrained by parameters such as ice thickness, ice mass, areal extent of the ice sheet, visco-elastic properties of the mantle and lithospheric thickness at the ice margin. Wingfield (1995) had previously hypothesized a forebulge within the southern North Sea, which migrated northwards as the ice sheet retreated. Similarly, Coles suggested (1998, 54) that the depression and any associated forebulge of the British-Irish and Fennoscandian ice sheet will have resulted in a north-west to south-east ridge across the North Sea basin. Previously, uncertainties existed, with Lambeck, in contrast to Peltier (1998), inferring that ice thickness in the British Isles was insufficient to produce a forebulge (Lambeck 1995; 1997).

More recently, Kiden *et al*. (2002) have provided evidence from both model and observational data for a forebulge. This was centred on Northsealand between Norway and Britain and extended through northwest Netherlands and northern Germany. These observations are backed up by the work by Vink *et al*. (2007), which indicates that the area that is now the southern North Sea subsided relative to Belgium between 8050 and 2850 cal BC probably as a result of forebulge collapse. The implications of forebulge collapse in the southern North Sea area are discussed in the next chapter.

Further, the North Sea basin has sunk considerably due to the weight of meltwater; a process known as hydro-isostasy (Johnston 1995). This means that areas that were affected by the forebulge effect, but not weighed down by meltwater, may have been higher than they are in the present day. Furthermore, sea-level fluctuations can be climate-induced, and oscillations (such as the North Atlantic Oscillation or, for the tropics, the El Niño Southern Oscillation) can result in the thermal expansion of ocean water (known as thermosteric). Greater salinity can also result in ocean expansion (halosteric), resulting in regional scales of sea-level change (Church *et al*. 2010b).

Problems still persist in understanding the interplay between glacial isostatic readjustment and eustatic changes. This may well be because the former has been typically studied by geophysists, mathematically modelling movements of the earth's surface. Data on eustatic sea-level changes, on the other hand, is gathered by geomorphologists using cores taken in the field. As Fairbridge says:

> "isostasy and eustasy are two intimately related geodynamic processes that can scarcely be understood or measured apart from each other, and yet, strangely enough, they have in the past been studied by specialists of two rather disparate disciplines, geophysics and geomorphology, the practitioners of each rarely possessing any training whatever in the other. This paradoxical situation may explain to some extent the many still unresolved problems that exist in both fields" (Fairbridge l983, 3).

Sea-level will also be affected by crustal response; however this complex relationship is only understood in the broadest of terms. As Simmons *et al*. point out “isostatic recovery is not nationally uniform because of uneven loading of ice, Britain having been at the southern margin of the last glaciation” (Simmons *et al*. 1981, 83). A further complexity is caused by wind action, which can result in decadal-level variability to sea-levels, and the complex response of the sea to (virtually random) wind forcing is poorly understood (Sturges and Hong 2001).

Complex modelling is required to take into consideration all these factors and to understand changes in the relative height of sea-level in different areas. A geophysical model produced by Lambeck in 1995 (GB-3) aimed to predict ice retreat across Great Britain. This used histories of the Fennoscandian and Laurentian ice sheets with contributions from northern Britain as well as more distant ice sheets. Lambeck proposed that post-glacial crustal rebound and hydro-isostasy were the two main factors causing sea-level change around the British Isles. Lambeck’s models predicted the magnitude of isostatic response of the Earth well; however, as he observed, the timing and rates of change did not correspond with the observed data.

Peltier had previously developed a model (ICE-1), which has been subsequently modified (ICE-2; ICE-3G; ICE-4G) and its parameters constantly refined (Peltier 1994; 1998; 2002; Shennan *et al*. 2002). These parameters are primarily mantle viscosity profiles, the weight and thickness of continental ice sheets, and additions to ^{14}C-controlled relative sea-level histories. Model ICE-4G proposed that the LGM ice volume was much lower than in previous models, and therefore significantly affecting predictions of post-glacial sea-level change. Contrary to Lambeck, Peltier suggested that rising sea-level along the Channel coast was controlled by the process of forebulge collapse (Peltier 1998).

Shennan and colleagues have produced two different studies of sea-level changes. Shennan *et al*. (2000) was based on relative sea-level predictions using Lambeck's (1995) Earth Models, whereas Shennan *et al*. (2002) was based on Peltier's model (Shennan *et al*. 2006). More recently, a growing realisation of the complexity and non-linear nature of sea-level rise led Horton *et al*. (2008) to take a different approach and use a set of General Circulation Models; although even these may not capture the full dynamical response of sea-level changes (PALSEA 2010).

The above summary serves to show that sea-level rise is a profoundly complex issue. A better understanding of its complexities, combined with increased observational data to constrain its modelling is essential to understand in any sort of detail the effects, perceptions and experience of early Holocene sea-level rise. Furthermore, there is a lack of chronological and spatial resolution in most modelling in relation to the time depth appropriate for assessing human perceptions and impacts of sea-level rise.

3.4 Methods of establishing relative sea-level change

Data used for the reconstruction of past sea-level changes typically have four attributes: a location; an age; an altitude in relation to a known datum; and an indicative meaning (relationship to a former sea-level). Once it is established that the relevant deposits are *in situ* and have not been transported, coordinates are taken in order to provide the location attribute. The age is usually determined using calibrated radiocarbon ages where appropriate samples are obtained.

Sea-level index points

A sea-level index point (SLIP) is a datum that can be employed to show vertical movements of sea-level when the above four pieces of information are established (Plassche 1986; Shennan 1982; Tooley 1982a; Shennan *et al*. 1983). SLIPs are employed to construct trends of relative sea-level where both the regional (eustatic, glacio-isostatic and hydro-isostatic) and the local (coastal morphology, sediment supply, tidal regime and terrestrial and fluvial input) factors may be identified. They use a wide variety of environmental data, such as lithostratigraphical and biostratigraphical indicators, and the potential vertical precision of transgressions (terrestrial to marine) or regressions (marine to terrestrial).

There are two established techniques in sea-level research that are used to interpret SLIPs: age/altitude analysis; and tendency analysis.

Age/altitude analysis

Age/altitude analysis determines the variation in sea-level by plotting SLIPs on a scatter graph with altitude as the dependent variable. This can be based on one site or across regions, and has been used to plot global sea-level rise. SLIPs plotted on an age/altitude graph should be shown as transgressive or regressive overlaps with an error box that demonstrates the range of the indicative meaning and a full assessment of altitudinal and age errors (Kidson and Heyworth 1979; Streif 1979; Shennan 1982; Tooley 1982b).

However, every sea-level index point has an altitudinal and age error, which means it is not possible to compare rates of relative sea-level change by calculating the gradient between a series of index points; the dataset needs to be smoothed before it can be analysed, resulting in a smooth exponential decay curve (Shennan *et al*. 1983) (see discussion in Chapter 3).

Tendency analysis

Tendency analysis is a simple and alternative approach that removes altitude altogether (Morrison 1976). It describes whether the point records an increase or decrease in water level or salinity at that location (Shennan 1983; Long 1992) or changes within the fossil assemblages. This is compared against age to estimate the direction of changes in marine conditions (a positive tendency is a transgressive one, and a negative tendency a regressive one). This can be used to identify local and also regional trends in RSL change. This method does, however, rely on a consistent definition of terms, particularly the terms transgression and regression. Tendency analysis has been undertaken in, for example, the Humber (Kirby 1999) and at Goldcliff in the Severn estuary (Bell *et al*. 2000, 327). A dual approach of using age/altitude graphs in association with analysis of the trend of marine influence has been examined by Shennan (1986a; 1987) and Long (1991, 199).

3.5 Problems with sea-level curves

There are, however, a number of problems involved in calculating SLIPs and therefore past sea-level changes. Heyworth and Kidson (1982) identified ten problem areas: levelling; identification of the horizon to be levelled; the relation of the water-table to sea-level; the relation of present tidal levels at the site to those at the nearest Tide Table port; variation of tidal range over time; exceptional tides, such as storm surges; consolidation of sediments as a result of gravitational compaction; changes in the relationship between a sea-level indicator and tide levels; and radiocarbon dating errors. Shennan (1986b) identified five major problems, reiterating some of the earlier ones: the ability to adequately record altitude; estimation of the original altitude of contacts; establishing the indicative meaning; adequately dating the sample; equating lithological change with sea-level change.

Problems such as levelling have become less of an issue in recent times due to improved technology, for example differential global positioning systems (GPS), although altitudinal errors still occur. These arise from the difficulties in identification of boundaries, the curvature of sampling rods, the measurement of depth, the angle of the borehole, and compaction. The latter is perhaps the single largest source of error involved in conventional sea-level analysis. The majority of sediments employed as SLIPs experience post-depositional displacement in altitude, mainly as the result of load causing compaction of underlying peats, clays and silts. Heyworth and Kidson (1982) suggest that woody peats can reduce in thickness by up to a half, whilst Sphagnum peats can be reduced by up to

90%. Jelgersma (1961) also claims that peat may compact by as much as 90%. This indicates that sea-level index points are likely to be routinely under-estimated. Correction factors can be applied (see for example Kidson and Heyworth 1973), however major variations between sediments and between sites mean that these are difficult to calculate and rarely applied.

Other problems include the difficulty of accurately dating the sediments, particularly given the possibility of contamination from older carbon within sediment already laid down, or younger carbon after deposition. Or indeed the ‘old wood effect’, that is, the problems of dating wood from long-lived trees, such as oak or juniper, which may already be many centuries old before inclusion within the deposit. This is particularly so if the dated wood is heartwood rather than sapwood.

Further, factors normally associated with changes in sea-level may not necessarily be consistent from one site to the next. One, therefore, needs to be aware of what exactly is being dated. For example an indicator such as the transition from a fenwood to a reedswamp, may reflect changes in groundwater levels rather than sea-level (Godwin 1940). While a transition from freshwater peat to saline conditions does not necessarily indicate the point at which the land is inundated. This is because the upper landward part of the marsh may only be flooded during the highest mean water conditions (such as spring tides), whilst the lower part of the marsh may be flooded more regularly or even permanently. Dating the landward part of the marsh would, therefore, not provide a date for the mean sea level, since actual submergence may not have occurred until well after this (Kearney 2001). Similarly, in narrow inlets or river estuaries, the tidal range will increase landwards, providing a false reading of sea-levels and it is in precisely these areas where sea-level investigations are conducted due to better preservation (Kidson and Heyworth 1979).

3.6 Scales of change, variation and tipping points

Perhaps the most significant issue, at least for this thesis, is the varying scales of observation by the above work. Cores taken through deposits may reflect local changes, however they are generally homogenised to build regional sea-level curves, conflating the local-scale with the large-scale. Although researchers have moved away from attempts to create a global curve (for example Mörner 1976a; Tooley 1985; Shennan 1987), they are still restricted to describing sea-level rise as a smooth, linear process, with curves worked out as an 'average' (for example Fig. 1.8 in Chapter 1). This is an important point, since it produces a sense that sea-level rise was slow, insidious and relatively stable, and therefore imperceptible to the individual.

Variation

As can be seen from the above discussion, sea-level changes relate to a whole series of complex interactions during and following deglaciation. This causes variability regionally and locally, complicating sea-level models and providing distinctive local sea-level 'fingerprints'. This has been acknowledged for some time (for example discussion in Mitrovica *et al*. 2010), even if it has rarely filtered through to the archaeological literature. As Douglas states: "the concept of eustasy, that is, a uniform change of sea level occurring everywhere … is an inadequate description of the deglaciation event" (Douglas 2001, 8).

Such variations are evident in Chapman and Lillie's work (2004), which, as noted in Chapter 1, provides one of the few discussions with the contemporary perception of environmental change as the central theme. They adopted a micro-scale approach to model sea-level rise in Holderness, East Yorkshire, demonstrating that a continuous sea-level rise in this topographic setting resulted in little initial landscape change. This was followed by a rapid inundation, on a scale that they suggest would certainly have been perceived, and perhaps dramatically so. This highlights how important local variations are to understanding perceptible changes and identifying tipping points. Such a micro-scale approach is helpful since it allows for the local perspective to be considered. It is on the local-scale that these very changes would have been observed, and responses developed (see below).

Thresholds and tipping points

As described, sea-level curves smooth out these variations and the uneven nature of sea-level rise, making a study of the local, that is to say human, perception of it virtually impossible. Rather than a continuous change depicted by a smooth curve, sea-level is an oscillating rise, and should be depicted by an interrupted curve (see Tooley 1978; Mörner 1976b; Kearney 2001 for more on the difference between smooth and oscillating curves).

Behre's dating work (2007) for the southern North Sea, for example, suggests that there was a very rapid rise in sea-level in the early Holocene with an estimated rise of 1.25cm per year (Behre 2007, 85). Taking a single generation as twenty-five years, this would be equal to 31.25 cm per generation; however, as we have seen above this would not have been a continuous process. Both Coles (1998) and Chapman and Lillie (2004) point out that depending on the topography, flooding would have occurred in fits and starts, with periods of relative calm followed by rapid flooding as thresholds are crossed and tipping points reached. A tiny perturbation can qualitatively alter the state or development of a system.

Furthermore, traditional descriptions of deglaciation can disguise the dynamics of this process. Studies of modern ice melt clearly show that it is not a slow and even process of melting at the sheet edge, but one prompted by dynamic, and at times dramatic, changes. For example, rapid recent decreases in the size of the Greenland ice sheet as a result modern global warming is not simply meltwater flowing from the surface and ice margins. Rather it is increases in the rate of calving of icebergs (Steffen *et al*. 2010). Meltwater penetrates cracks, crevasses and shafts through the ice sheet down to the bedrock. This process can lubricate large sections of ice over the ground causing it to move, until a tipping point is reached and vast amounts of ice suddenly detach (Steffen *et al*. 2010; Hansen 2005; Zwally *et al*. 2002; Joughin *et al*. 2004). This has an immediate effect on the sea's levels. Such a process also has a positive feedback resulting in ever more rapid decreases in the ice sheet and associated sea-level rise as a result of increased melting of the ice margin.

This dynamic description is perhaps a more accurate one of early Holocene deglaciation and sea-level rise than the homogenised, relatively stable picture often presented. And indeed Clark *et al*. (2012) tentatively suggest the last deglaciation of the British-Irish ice sheet, particularly along the marine margins, was likely to have been rapid and dramatic.

Certainly, ice sheet instability is evident from the last deglaciation where a growing body of evidence indicates sudden collapses of the Laurentide ice sheet. This resulted in large-scale releases of meltwater, leading to catastrophic global sea-level rise. One of these meltwater pulse events rapidly raised sea-level by as much as five metres in the late Mesolithic period over a relatively short period around 5650 cal BC (MWP-2) (Blanchon and Shaw 1995; Bird *et al*. 2007; Lambeck *et al*. 2010; Yu *et al*. 2007); such a rise would not only have been perceptible, but potentially catastrophic. It has been argued that atmospheric circulation changed abruptly as a result of this process "switching between glacial and interglacial conditions in less than a decade" (Blanchon and Shaw 1995, 4).

This brings to mind the brief but rapid (although highly variable) return to cooler conditions between 10,950 and 9650 cal BC known in Britain as the Loch Lomond stadial and on the Continent as the Younger Dryas (named after the tundra wildflower *Dryas octopetala*). The Younger Dryas may have been triggered by meltwater disruption of warm water in the northern Atlantic (Eren 2012a). A meltwater pulse event (MWP-1A) around this time led to a sea-level rise of around nineteen metres in 500 years (Huang and Tian 2008). Another meltwater pulse event (MWP-1B) occurred around 9550 cal BC to 9050 cal BC, raising sea-levels by around fifteen metres (Huang and Tian 2008).

Similarly, rapid meltwater pulse events, primarily the draining of freshwater lakes dammed by the Laurentide ice sheet, are likely to have triggered the '8.2 kya cold event' (Huang and Tian 2008; Bird *et al*. 2007). This event occurred when the ice dam blocking the drainage of the large glacial lakes Agassiz and Ojibway collapsed around 6250 cal BC, allowing the lakes to flood into the Labrador Sea. This resulted in an abrupt rise of global mean sea-level (Barber *et al*. 1997; Clarke *et al*. 2004; Hijma and Cohen 2010). Archaeological signatures for this event may be evident in a sea-level jump in the Rhine/Meuse delta (Hijma and Cohen 2011; discussed further in Chapter 4). This event also resulted in a rapid drop in the air temperature, which may have remained depressed for the following two hundred years (Thomas *et al*. 2007; Garnett *et al*. 2004). Abrupt climate events such as these will have had an impact on contemporary populations (Blockley 2009).

Other short-term events include tsunami, which would have amplified the impact of sea-level rise, and irreversibly affected the landscape. Coring of valley deposits at Howick Burn, Northumberland has recorded coarse-grained and 'chaotic' deposits representing a dramatic short-lived, high-energy event that interrupted an otherwise quiet valley environment. These deposits date to the later part of the seventh millennium cal BC (*c*. 6100 cal BC) (Boomer *et al*. 2007; also Weninger *et al*. 2008), and are therefore broadly contemporary with similar deposits thought to be associated with the Storegga Slide tsunami.

The suggestion that there was a major tsunami generated by an underwater slide off the coast of Norway during the Mesolithic was first made by Svendsen (Weninger *et al*. 2008), when associated deposits were identified along the Norwegian coast. Corresponding deposits have since been identified in eastern Scotland (Dawson *et al*. 1990; Long *et al*. 1989; Smith *et al*. 1985; 2004), as well as in a number of other regions around the North Atlantic, seemingly reaching as far as the east coast of Greenland (Wagner *et al*. 2007).

Following the submarine slide, a tidal wave was generated that could have crossed the North Atlantic within three hours (Bondevik *et al*. 2005). Along the coast the first sign of it would have been the withdrawal of water, with the sea-level dropping by perhaps twenty metres, followed by the first wave (Weninger *et al*. 2008). The size of the wave varied depending on the region and with those closest to the slide being hit the hardest. It has been suggested that along the Norwegian coast, opposite the slide, it may have been ten to twelve metres high, while on the east coast of Scotland it may have been three to five metres high (Smith *et al*. 2004; Weninger *et al*. 2008). Deposits from the Faroes and Shetland Islands suggest that it may well have exceeded twenty metres in height (Bondevik *et al*. 2005).

Further waves are likely to have followed. At Greenland four were visible in the deposits (Wagner *et al*. 2007); at Howick there were perhaps two (Boomer *et al*. 2007). The coincidence of the tsunami very soon after the '8.2 kya cold event' is likely to have increased the impact (Weninger *et al*. 2008). The 3D seismic analyses of the southern North Sea have so far not recorded signs of the impact of the Storegga tsunami. However, it clearly would have had a considerable effect on the landscape and on the inhabitants, as shown in the map created by Weninger *et al*. (2008), which illustrates the hypothetical impact zones on the North Sea plain (Fig. 3.2). These lowlands with their gently inclined coastline, salt-marshes and mud-flats (Chapter 4) would have been especially vulnerable to the tsunami, the force of which would have been funnelled up river valleys and with islands in particular feeling its full force (Weninger *et al*. 2008).

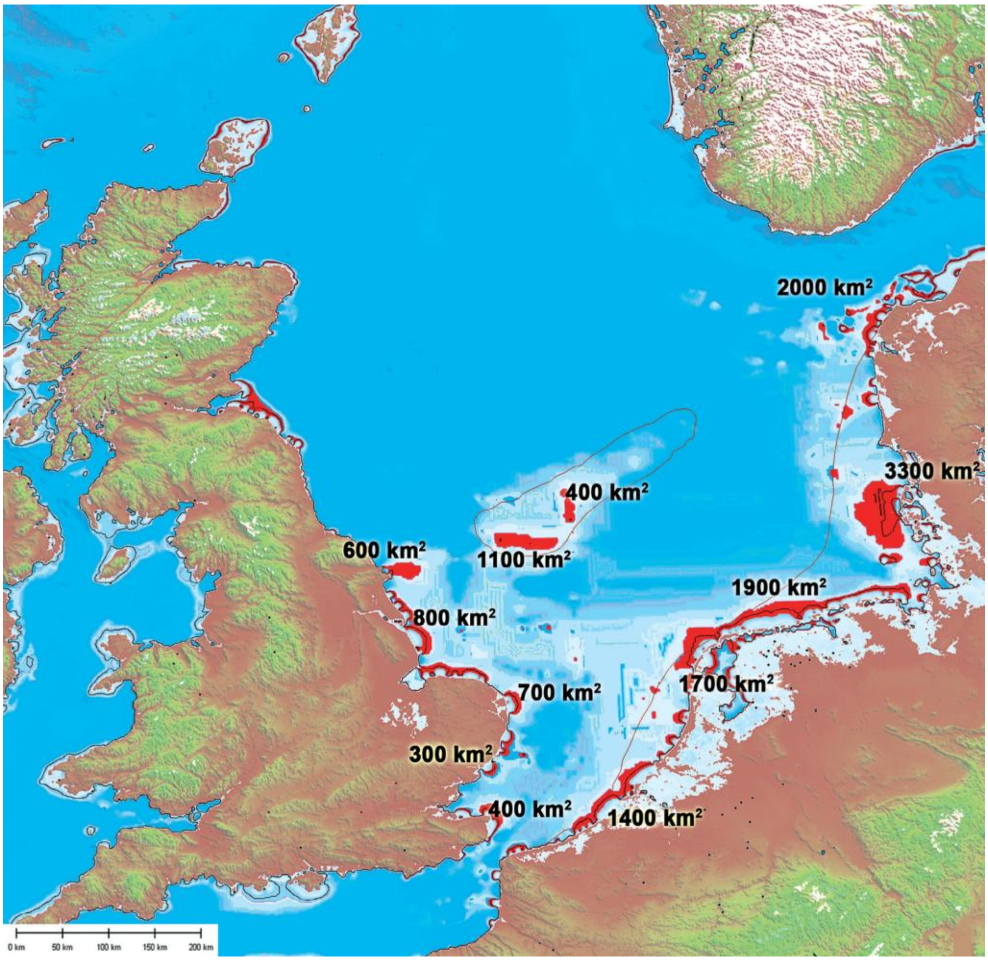


Fig. 3.2: Hypothetical impact zones of the tsunami on the North Sea plain. (From Weninger *et al*. 2008, 12).

Arguably, it is the regions most vulnerable to impact, the coastline and lower reaches of river valleys, that were the most attractive locations for human settlement. Weninger *et al*. (2008, 16) have suggested that "a number of local bands, or possibly a regional dialectical tribe" may have been extinguished. Weninger also gives some consideration to other elements of the impact, for example the loss of productive areas, shellfish beds, fixed fishing facilities and stored food (Weninger *et al*. 2008).

The key point here is that these abrupt events contrast with the stable depictions of sea-level rise. Sea-level rise, like climate change, can be characterised by extreme unevenness. Periods, during which little perceptible change occurred, succeeded by major, sometimes catastrophic, changes. Sea-level rise, as with other complex and open systems, is dynamic and non-linear, producing multiple, and essentially unpredictable, effects.

In this way, changes are irreducible to simple or single models of processes, and rapid transformations can occur as thresholds are breached and tipping points reached. Changes can happen abruptly at a moment when the system switches. They are dynamic and potentially irreversible.

Scales of change

Studies of sea-level rise tend to be, by their nature, large-scale. They generally cover large regions, countries, continents or even the whole globe. Although these pick-up small-scale, short-term events, their importance is generally considered in how they fit into and help revise broad, averaged-out sea-level curves.

This is also true of studies of modern climate change, which is monitored, modelled, and averaged at a large-scale (Hulme and Barrow 1997). One such example is used as the main climate indicator for the United Kingdom. This is the mean annual temperature for central England – also known as Central England Temperatures (or CET), and is the longest record of temperatures in the world with monthly data going back to 1659. Meteorological information is gathered from weather stations within a triangular area enclosed by London, Bristol and Lancashire, and records are taken daily. By plotting annual averages across this area, broad trends, such as increasing temperatures, can be recorded and reported on (Hulme and Barrow 1997). However, in this process short-term anomalies, such as single, sharp cold snaps or periods of sudden downpours, are smoothed out.

Although highly important (and such averaging is a necessary part of monitoring global climate change), these large-scale models do not deal with the dynamism and uncertainties of shorter-term variations. They do not consider the periods of rapid change; the small-scale perturbations that can tip a weather system in one direction or another. Sea-level rise, like climate change, is non-linear and it affects people in a diverse and unpredictable set of ways.

Neither do large-scale models afford much consideration of the human aspect – the way people either perceived or reacted to the way their landscape changed with loss of land and resources. The local perspective is rarely considered. And yet it is at the local-scale that these very changes would have been observed (Chapter 5), and appropriate responses developed (Chapter 6). The processes of change described in this chapter unfolded on a local scale; they were perceived locally and formed part of everyday life. And although we now know sea-level rise to have been a global phenomenon with a long chronology, it would not have been understood as such by Mesolithic communities. The changes would have been experienced within living time.

In many ways the difference between the large-scale and local-scale is similar to that between the approaches of modern climate change scientists *versus* that of anthropologists. On the one hand climate change scientists monitor global climate through instruments (measuring, for example, temperature, rainfall, and atmospheric pressure), and from these produce large-scale models of change. On the other hand anthropologists engage with ‘traditional ecological knowledge’ to help understand how the people living on the land (the local level) perceive their environment to have changed. Frequently the local view of change is quite different to the one of climate change scientists, and people are affected in ways that are not always obvious, or predictable, from the large-scale models. Linking with the discussion in Chapter 2, the divide between society and nature is reflected in the very notion of a measurable climate. That is to say, a climate separate from its cultural reading and interpretation.

Critically, these studies show that when scientists talk in the abstract of climate, the locals talk of weather (see Ingold and Kurtilla 2000, and papers in Krupnik and Jolly 2002). As Ingold and Kurtilla state “climate is recorded, weather experienced” (Ingold and Kurtilla 2000, 187). In this way, the difference between studying sea-level rise at the large-scale as compared to the local-scale is also the difference between *recording* it and the *experience* of it. It is this – the experience – that is of most interest to this thesis.

For local-scale one could also read local-perspective, for it is not a spatial scale at all but a certain perspective – one that attempts to capture the experiences of life. The local-scale is the activity in a locality; it is the engagement with it, and the knowledge and experience of it. As such, local-scale is not a fixed entity and can be just as much about the community level, as the individual. It is the most appropriate scale to study the human experience. Local-scale is defined by a particular identity, constitution and knowledge, created by inhabiting and dwelling in the land.

Large-scale models of climate change are not part of the same continuum as the local-scale, but something entirely different. The large-scale is abstract and unreal; it is based on averages. The local-scale on the other hand is experiential; it is about the everyday lives of local people. By studying the local-scale, we are also imposing a temporal scale too, for it is the lived experience that is of prime interest. To understand the local-scale is to understand the more tangible impacts of sea-level rise and climate change.

Models of human behaviour that do not discuss the local-scale miss out on both the major effect and fine nuances of environmental change, and are therefore limited. This is not to set up a dichotomy between the two different scales; for large-scale models are also important, but physical changes were appreciated at a local scale – on the ground so to speak. Discussions of past sea-level rise, and indeed climate change, need to bridge this analytical gap and adopt an approach at a more human scale.

A similar claim can be made concerning the view arising from the seismic surveys described in Chapter 1. These are projects which concentrate on large swathes of land, mapping the Holocene topography in some detail. However, these large-scale studies cannot easily consider the human aspect of sea-level rise – the way people either perceived or reacted to it and the associated loss of land and resources. Such a relatively coarse scale of approach does not easily help comprehend the way the sea would have risen haphazardly as thresholds were crossed.

3.7 Chapter summary

This chapter has described the controlling processes of relative sea-level rise during the early Holocene in the North Sea basin. The two main processes are eustatic sea-level rise (that is the return of water to the ocean basins since the LGM), and isostatic readjustment (the readjustment of the Earth's surface following the removal of ice-loads). There are two further processes that play an important role; the forebulge effect (the upward bulge of the Earth's surface around the sunken ice margin), and hydro-isostasy (the sinking of the North Sea basin due to the weight of meltwater).

However, sea-level rise is highly complex and the amount and timing of eustatic and isostatic sea-level rise is far from certain, whilst crustal response is only understood in the broadest of terms. Sea-level rise is dependant on a web of other processes, many of which are only poorly understood themselves, such as mantle viscosity and the weight and thickness of ice sheets. Sea-level rise also shows significant spatial variation, and contrasting changes are recorded at different locations around the North Sea and Channel/Manche coastline. This picture is further complicated by the fact that some areas are much better studied than others, providing a rather patchy record. Complexities of modelling local-sale variations were also discussed, and which can significantly alter sea-levels.

The methods for establishing sea-level curves are discussed, such as the use of sea-level index points and the techniques used to interpret these; namely age/altitude analysis and tendency analysis. Problems with the methods of producing sea-level curves are also outlined.

The point in laying out much of this detail was to show that sea-level rise is both complex and dynamic. General models cannot deal adequately with non-linear dynamics. Far from being a slow insidious process of inundation, sea-level rise occurred in quick, abrupt changes. Small changes caused thresholds to be crossed and tipped large systems over the edge. Indeed the North Sea coast can be described as a 'threshold' place. Its low-lying, largely flat, and highly dynamic nature means that small changes will have led to thresholds, such as natural coastal-barrier beaches and dune systems, being breached, with major consequences.

This chapter discussed the differing scales of change and the 'smoothed-out' nature of sea-level curves was pointed out. Sea-level curves highlight large-scale changes, but are not conducive to the study of the local-scale perspective; that is to say, human perceptions of change. These curves do not capture the full dynamic response of sea-level changes. Nor do they capture the non-linear nature of sea-level rise, thus making local-scale past sea-levels difficult to predict. It has also been suggested that although sea-level rise and climate change occurred globally and on a millennial-scale, it unfolded at a local and community level and was experienced at this level. It was experienced through practices whereby people and particular environmental features came together.

Chapter 4

Thinking the imagined land

"One does not discover new lands without consenting to lose sight of the shore for a very long time" André Gide 'The Counterfeiters' 1925.

4.1 Introduction

One of the problems discussing Northsealand in anything other than the most perfunctory of terms is that it remains, to a greater or lesser extent, an abstract landscape. Unavailable to walk through and analyse on the ground one is left to imagine what it may have looked like. Consequently, speculating on the people that once lived there becomes that much more difficult.

This chapter draws together much of the new and emerging research on this landscape in an attempt to reveal something of the character of Northsealand. The information is based on the available geological, borehole, bathymetric and seismic data, which is sufficient to be able to identify some key topographical features and drainage patterns. Combined with evidence from present-day coastal and intertidal sites, with information from sea-level curves, this allows a preliminary characterisation of the submerged landscape.

The archaeological information is, as might be expected, extremely sparse and difficult to date. And where sites do occur their discovery is often serendipitous and information about them tends to be either very general or very local. It should also be noted that although an attempt has been made to integrate information from both UK waters and those belonging to continental countries, the information is heavily skewed towards the area within twelve nautical miles of the British coast. This is largely due to the impressive amount of work funded by the Marine Aggregate Levy Sustainability Fund (MALSF) (see Chapter 7), most notably the four Regional Environmental Characterisation (REC) reports. At this stage, comparable evidence simply barely exists from the continental side (with the Rhine/Meuse area being a notable exception). Such landscape pictures as presented below are therefore broad brush, with much extrapolation. They should not be considered reconstructions in the true sense of the word.

A comprehensive review of Mesolithic sites that border the southern North Sea and Channel/Manche has not been attempted; the work for which would require a separate PhD. Instead, this chapter will provide an overview of the evidence from both onshore and offshore sites that offers a glimpse of the landscape. It also highlights the potential for understanding the impact of sea-level rise on communities and their responses to it.

For the purposes of this thesis the study area has been divided into three geographical areas (Fig. 4.1). The first (Area 1) incorporates the north-western river system in the upper southern North Sea, where the main topographic feature is the Outer Silver Pit, originally a large lake and later a tidal inlet. The second (Area 2) is formed by the lower part of the southern North Sea where the rivers drained to the south, converging on the Lobourg Channel before entering the Dover gorge. This passes between the Weald-Artois chalk ridge and which would have been a major topographic feature. And then finally Area 3 comprises the eastern Channel/Manche area, which would have been dominated by the wide Channel River, a continuation of the Lobourg Channel, and which flowed southwest to the Channel embayment.

The available data discussed below indicates that in general terms, Northsealand can be described as a wet, mostly low-lying, flat and fluvially dominated landscape. The rivers, in most instances, cutting with relative ease through sands and gravels to form networks of braided channels separated by swamp, reed bed and carr woodland. That said, there were areas of higher land, and the topography was in places varied. As the Devensian ice sheet retreated, the Northsealand landscape was likely to have been barren tundra crossed by moraines and rivers, much like northern Canada today. The main topographic highs will have been provided by ridges and outcrops of chalk, often being continuations of the chalkland relief that survives today on dry land. Upswelling salt domes will also have formed low hills.

Discussion of this landscape needs to be set against contemporaneous rising mean temperatures, which allowed the northwards spread of thermophilous vegetation and animals (Simmons *et al*. 1981; Bell and Walker 2005). Huntley and Birks' (1983) pollen isochron maps for Europe show the suggested spread of woodland through the region. In broad terms, at the start of the Holocene, vegetation cover is likely to have comprised herbs and dwarf shrubs such as juniper, birch and willow. As temperatures began to rise the late glacial tundra landscape was successively replaced with trees such as scots pine, birch and hazel expanding across the area. By around 9000 cal BC parts of the area may well have been well-wooded with dense mixed deciduous woodland of thermophilious trees such as elm, oak and hazel, subsequently including alder, ash and lime. Cold-climate herbivores gave way to red- and roe-deer, elk and pig. Throughout the Mesolithic period inundation is likely to have caused forest die-back due to saline water ingress (see Chapter 5). This would have formed marshland and tidal flats in the low-lying areas, expanding across the area and dramatically affecting the appearance of the landscape. Estuaries, embayments, tidal creeks and salt marsh developed over these areas as sea levels rose and the coastline pushed inland. These wetlands are likely, at first at least, to have provided enhanced resources, which may well have attracted further settlement (Coles 1999).

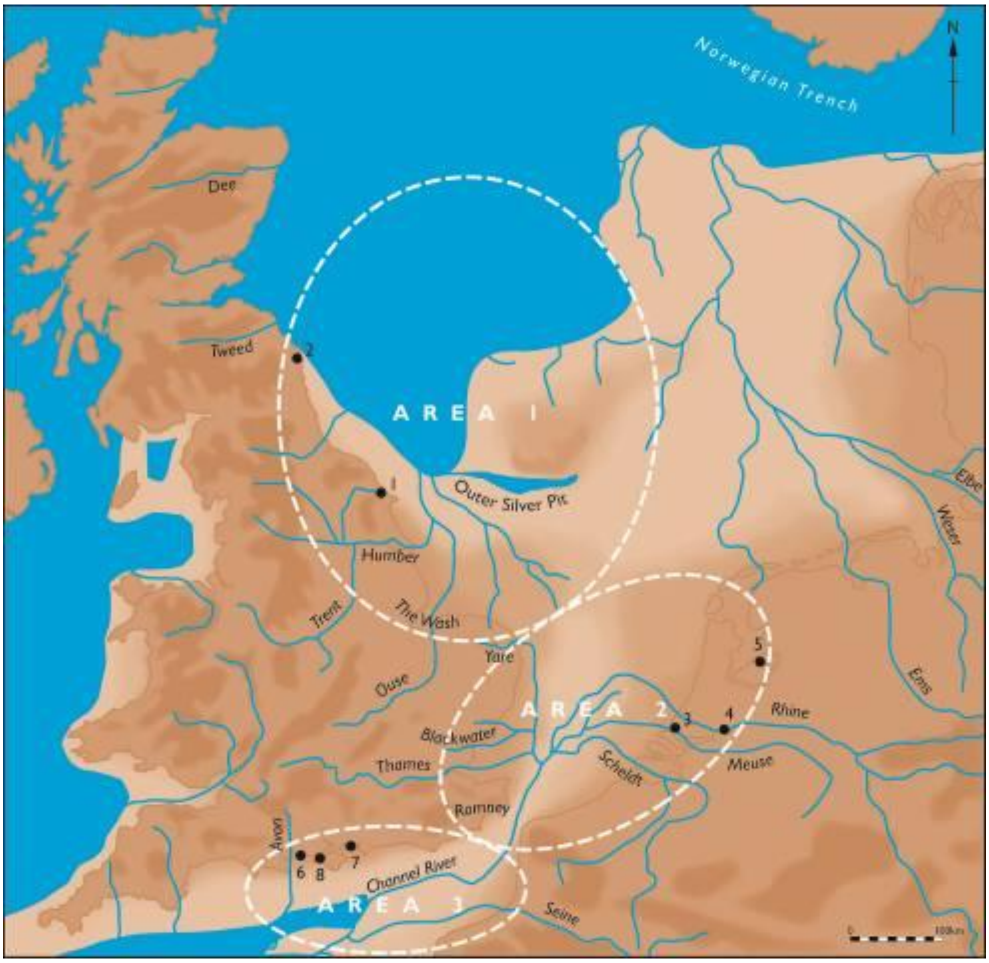


Fig. 4.1: Map showing the location of the three areas discussed, as well as sites mentioned in the text. 1: Star Carr; 2: Howick; 3: Europoort; 4: Hardinxveld-Giessendam; 5: Flevoland; 6: Hengistbury Head; 7: Langstone Harbour; 8: Bouldnor Cliff.

4.2 Area 1: The Outer Silver Pit region (upper southern North Sea)

This northern-most area, including the Outer Silver Pit, lay under the Devensian ice sheet during the last glaciation (Chapter 3, Fig. 3.1). As the ice retreated, the till of the Bolders Bank formation (a stiff greyish brown sediment) was laid down covering much of the area, whilst similarly deposited Botney Cut Formation deposits infilled sub-glacial fluvial valleys (Tappin *et al*. 2011). The Boulders Bank Formation is similar to the glacial till found in the north of England and likely to have had a gleyed basic soil (Cameron 1992; Fitch 2011).

Part of this landscape has been studied and characterised by the MALSF-funded North Sea Palaeolandscapes Project (NSPP) conducted by Birmingham University (Fig. 4.2; Gaffney *et al*. 2007; 2009). Much of this area would have been a low lying plain, the main topographic feature being the deep east-west Outer Silver Pit (Fig. 4.2b) – an extensive lake measuring around 100 km long and 30 km wide during the early Holocene. As a result of sea-level rise this lake was breached, possibly around the middle of the eighth millennium cal BC, becoming a marine outlet with evidence for strong tidal currents. The Outer Silver Pit is likely to have been an important aggregation place for humans, described by Fitch as “the *axis cruces* within the Mesolithic landscape” (2011, 259). It was surrounded by expansive wetlands and salt marshes and a number of large meandering river networks with numerous small tributaries feeding into it (Fitch *et al*. 2005; Gaffney *et al*. 2007). The Shotton Channel (Fig. 4.2a), the largest of these rivers to the north of the Outer Silver Pit and incised into the underlying late Pleistocene Dogger Bank formation, was over 600 m wide with a very substantial flood plain (Fitch 2011) and would itself have been a major Holocene landscape feature until inundation. Two substantial sand banks are evident within the Outer Silver Pit, while a further bank referred to as the Outer Well Bank, on the northern lakeside/coastline, would have provided a localised high area (Fig. 4.2d).

A valley, 140 m across, was observed on the southwestern side of the NSPP study area opposite the Wash and Humber estuary and investigated as part of the Humber REC (Fig. 4.2g; Gearey *et al*. forthcoming). Three vibrocores were extracted from across this feature, providing evidence for a late Devensian and early Holocene sequence. Analysis of peat deposits from them indicates deposition between 7300 and 6820 cal BC within a relatively shallow and sluggish reedswamp environment fringed by mature deciduous woodland dominated by oak and hazel. Inundation had occurred by 4660–3230 cal BC (Gearey *et al*. forthcoming).

Further topographic features evident across this flat Holocene landscape derive from salt tectonics, and include salt domes creating hillocks of a few metres in height, or, where collapsed, a ring of higher ground with a central, probably marshy, depression (graben collapse) (Fig. 4.2e; Holford *et al*. 2007). Seismic surveys as part of the NSPP reveal that the rivers deviate to respect these features indicating a chronological relationship between them. Although the salt domes would not have been high, in this flat area they are likely to have been visible topographic features and ideal for locating settlements, while the geological strata exposed by graben collapse may well have been a useful source of lithics (Fitch *et al*. 2007a, 107).

These features probably all originate from the end of the last glaciation, however, the techniques used have not been successful at establishing a firm chronology for any of them and the maps produced as part of the NSPP should be seen as palimpsests.

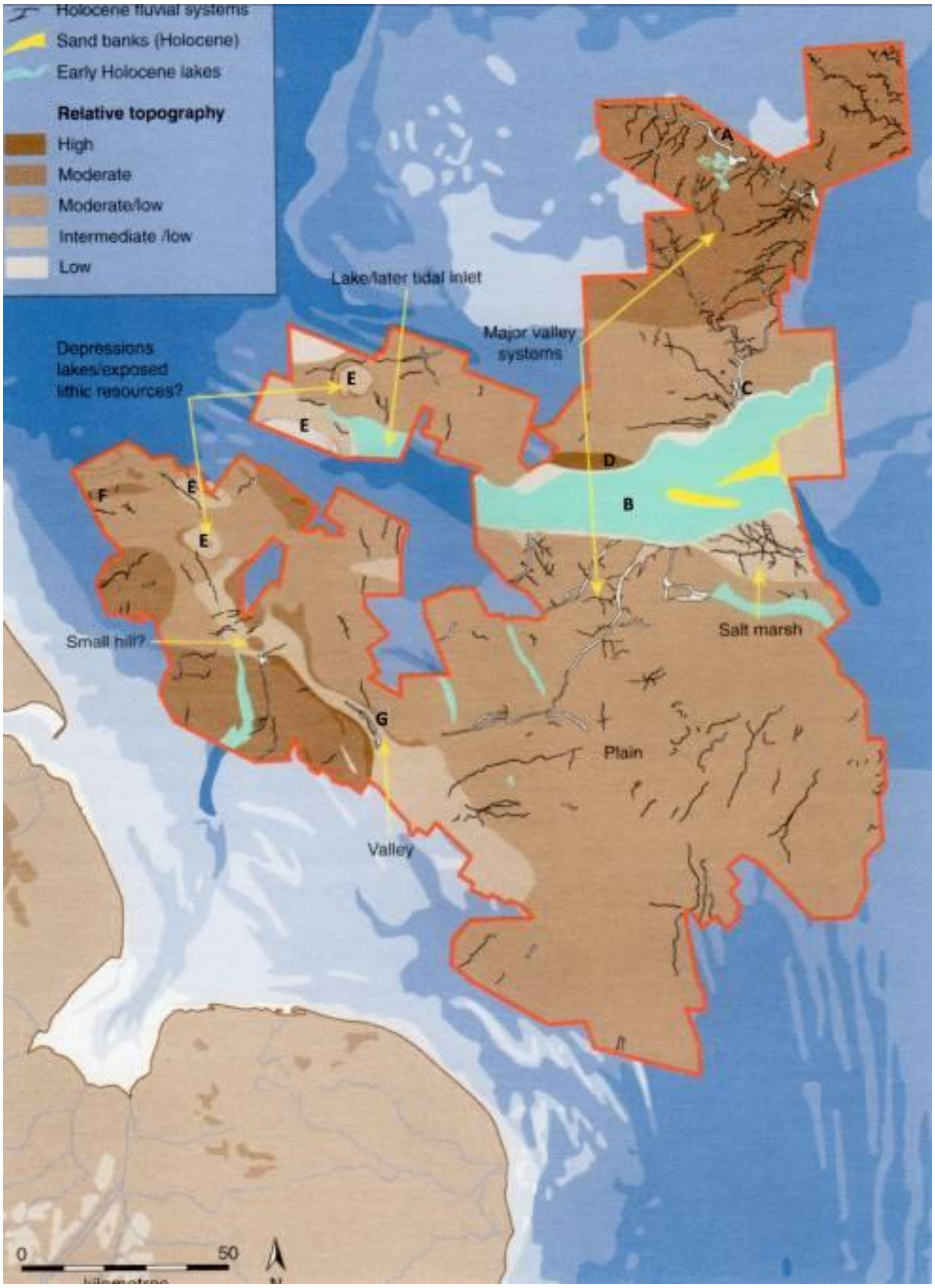


Fig. 4.2: A palimpsest of the mapped Holocene features within the NSPP study area showing river systems, including the Shotton Channel (A), draining south towards the Outer Silver Pit lake/tidal inlet (B), and the later development of small estuaries (C) and two moribund sand banks formed in an estuarine environment. The Outer Well Bank (D) can also be seen, as well as salt tectonic structures (both domes and collapsed structures) (E), the eastern tip of the Flamborough Head disturbance (F), and a north-south valley (G). (Modified from Gaffney *et al*. 2009, 140).

Between the area recorded by Birmingham University and the modern coast there appears to have been a significant amount of recent erosion of deposits, which is likely to have led to a loss of sites (Bicket 2012). Cretaceous chalk deposits evident now on land in eastern England can be traced into the eastern side of the submerged area, around the Wash and further north along the Yorkshire coast. This easily weathered rounded calcareous topography would have determined the nature of vegetation on this side. In particular, a linear spur of chalk, known as the Flamborough Head disturbance, is evident, extending from the Humber coastline out towards the Outer Silver Pit (Fig. 4.2f; Fitch *et al*. 2007b; Gaffney *et al*. 2009). This would have formed a ridge of higher ground dominating the local topography.

Mesolithic activity recorded along the current coastline, for example at Kelling Heath, north Norfolk (Sainty 1924), will likely have continued into the now-submerged area. The major embayment of the Wash, as well as the Humber estuary, on the western side of Area 1, would have formed major access ways into (what is now) mainland Britain.

As well as the Outer Silver Pit, a number of other 'deeps' are visible on bathymetric maps over much of the area, such as Sand Hole, Silver Pit, Sole Pit, Coal Pit, Well Hole, and Markham's Hole (Figs. 4.3 and 4.4). There is much debate about how these deeps were formed and there may well be a number of different processes involved, but they are mainly incised into the Bolders Bank Formation and may be fluvial valleys cut as the ice sheet retreated (Tappin *et al*. 2011, 96; Dix and Sturt 2011, 9). This suggests that they would have been evident as landscape features throughout the Mesolithic period until submergence, possibly as lakes and deeply eroded river valleys. For example, Tappin *et al*. (2011, 98) suggest Sand Hole and Silver Pit would have drained the Humber and Wash respectively (Fig. 4.4). Markham’s Hole is also likely to have been a freshwater lake during the early Holocene.

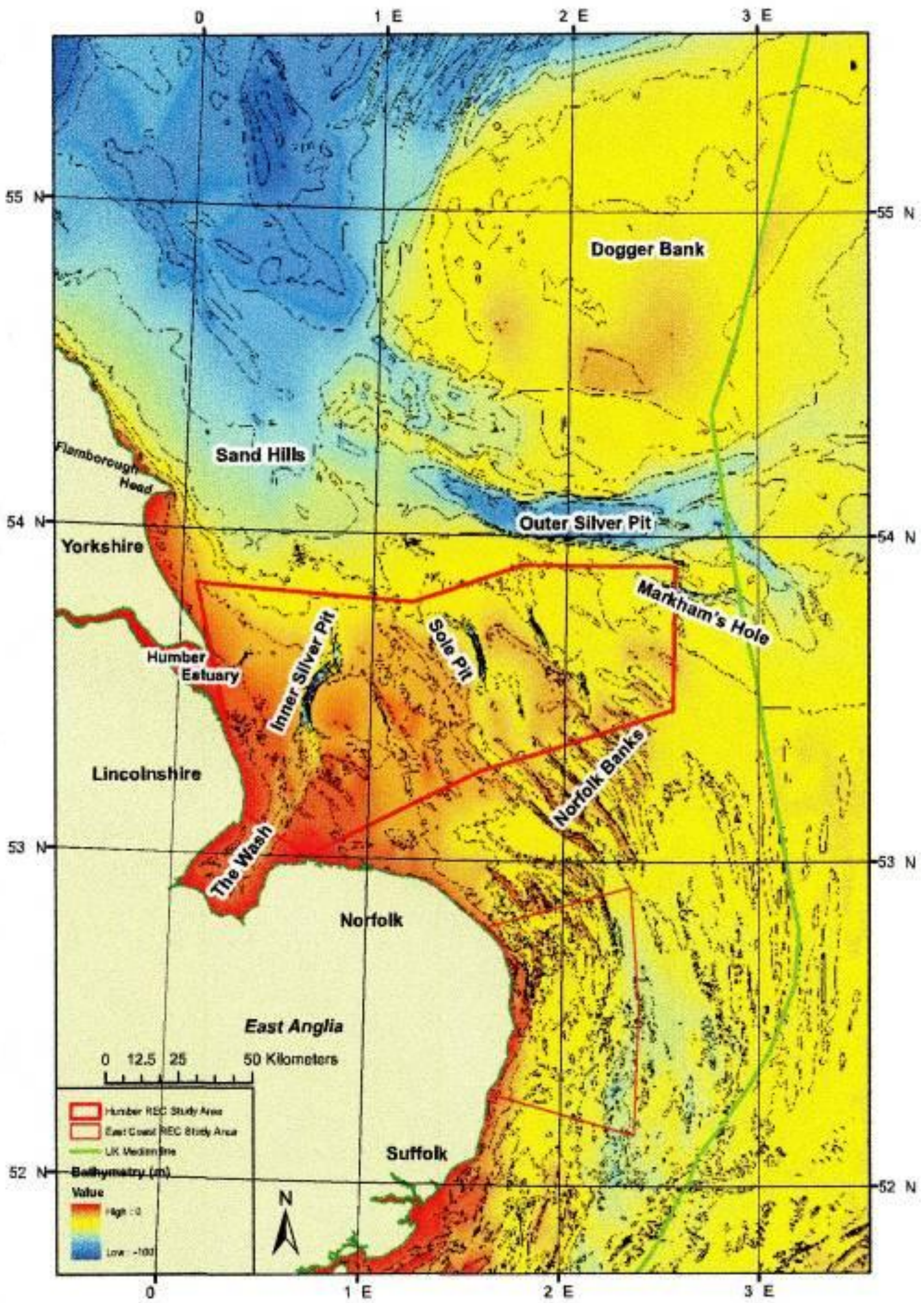


Fig. 4.3: Bathymetry of the western side of Area 1, showing Humber and East Coast REC study areas. (From Tappin *et al*. 2011, 5).

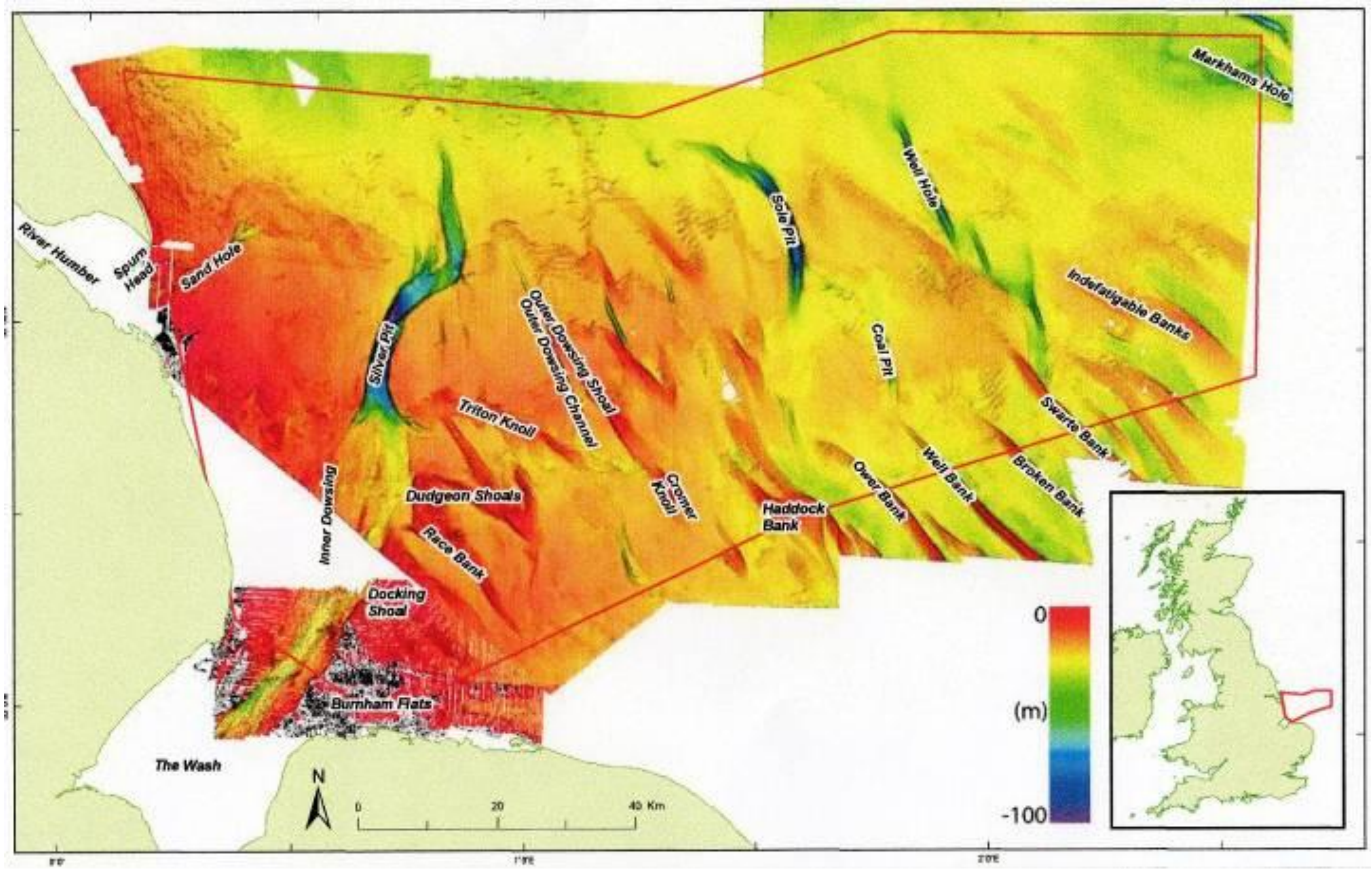


Fig. 4.4: Physical features and named localities in the Humber REC study area (Tappin *et al*. 2011, 81).

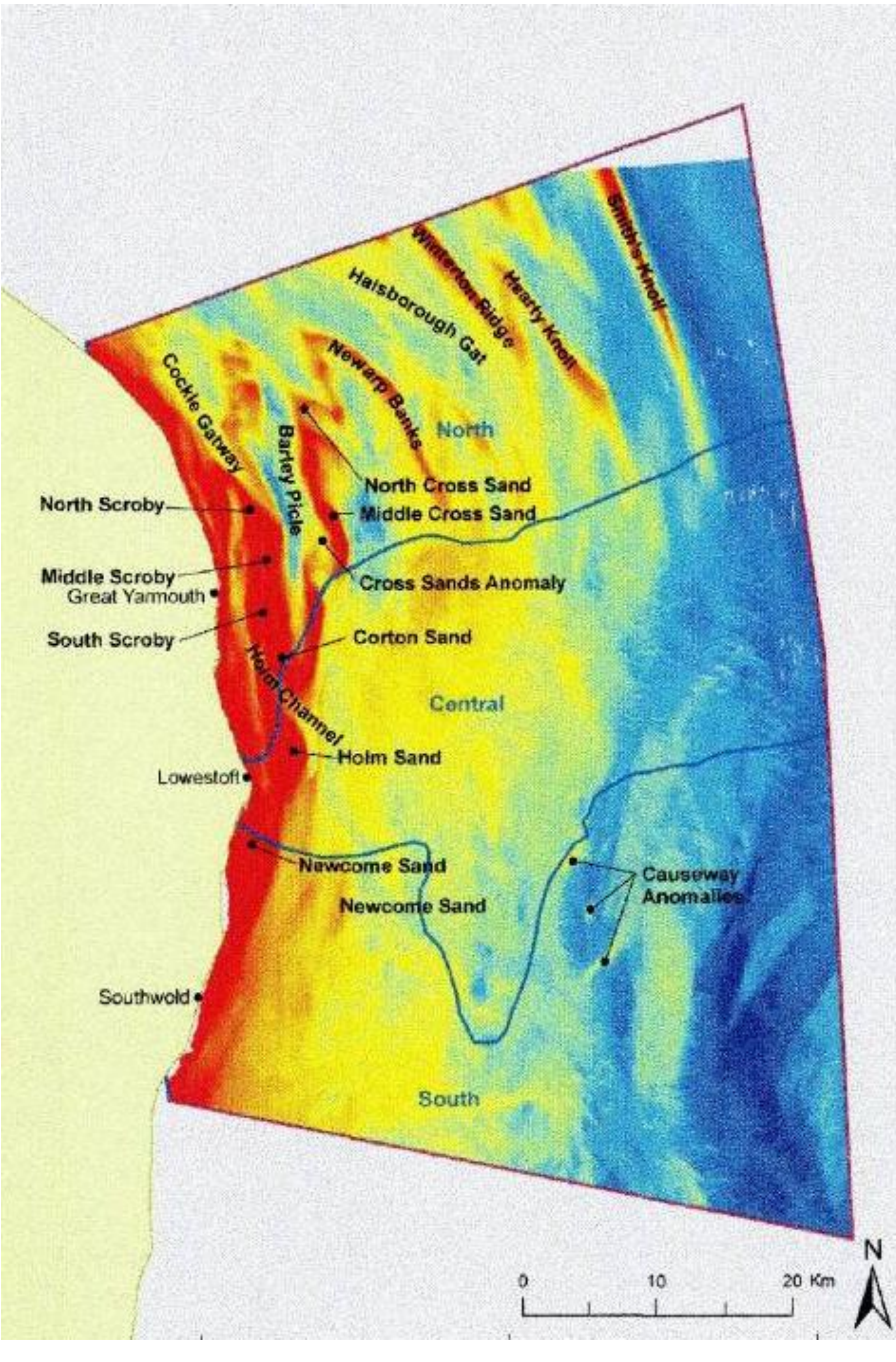


Fig. 4.5: Physical features and named localities in the East Coast REC study area (Limpenny *et al*. 2011, 73).

Further south and beyond the limit of the former ice sheet, the drift geology is dominated by periglacial windblown sands and gravelly sands deposited as the ice sheet retreated (Limpenny *et al*. 2011). The topography of the present day seabed, particularly off the coast of East Anglia, is somewhat more uneven than the area to the north, resulting from distinctive bedrock outcrops of older geological strata.

A particularly dramatic feature in this area is the Cross Sands Anomaly, a 165 m long, 30 m wide and 13 m high east–west flat-topped and steep-sided ovoid protrusion of chalk (Fig. 4.6 and see Fig. 4.5 for location; also Fig. 5.7 in Chapter 5), located in the Barley Picle channel. This feature would have been present and highly visible throughout the Mesolithic period. As Murphy (2007, 10) points out, in this flat area it is likely to have been visible for miles around. It would have been a known and perhaps named landscape feature, possibly with spiritual significance to communities in the area. It may also have provided a source for flint, and could include cave systems, which could have been used as the focus for acts of formal deposition, or, as with Aveline's Hole in Somerset and other caves in England and Wales, the burial of human remains (*eg* Conneller 2006). As the landscape around it flooded, the Cross Sands Anomaly will have, for a period, stood proud of the water as an island, and again was perhaps venerated, much like the sacred Saami island of Ukonsaari (Bradley 2000). If caves were present, shell middens may have been created within them as they were in caves in the Oban region and Inner Sound in Scotland (*eg* Hardy and Wickham-Jones 2009; Chatterton 2006).

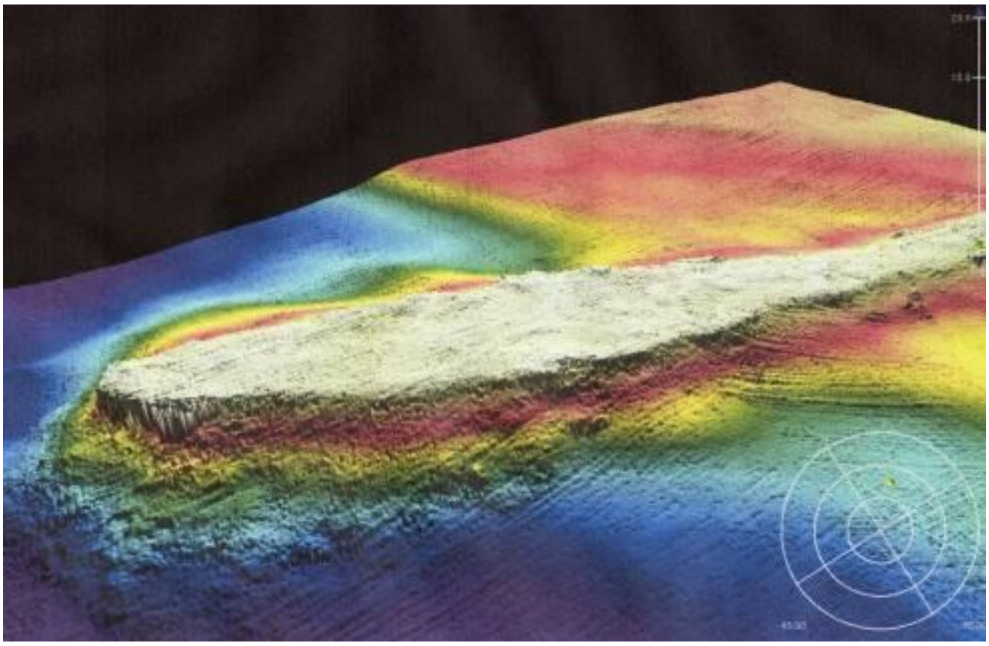


Fig. 4.6: The Cross Sands Anomaly geological feature off the East Anglian Coast (Murphy 2007, 10). Contains Maritime and Coastguard Agency data © Crown copyright and database right.

The coastline at the start of the Holocene, as proposed by Behre (2007) (Fig. 1.9), shows an embayment to the north of Area 1, which by the middle of the tenth millennium had extended south along the east coast of Britain as far as Flamborough Head (Figs. 1.3 and 1.10). The Outer Silver Pit lake may have been breached by the middle of the eighth millennium cal BC and certainly by the beginning of the seventh (Figs. 1.3 and 1.11) to become an extensive estuary. With the rising sea-levels and submergence of the land, intertidal mud, fine-grained silt and peat of the Elbow Formation was laid down covering much of this area.

The origins of many of the sand banks evident in Area 1 (Figs. 1.5 and 4.4), and indeed across the North Sea and Channel/Manche, have not been studied in detail. However, where they have, for example the Outer Norfolk Banks (Fig. 4.3), they appear to post-date marine transgression, since they overlie the till of the Bolder Bank Formation and comprise reworked glacial sands (Tappin *et al*. 2011, 101–2). The NSPP seismic survey has also revealed an early Holocene landscape underlying the Dogger Bank, which again suggests that these banks formed after the land had submerged (as noted in Chapter 1) (Gaffney *et al*. 2009, 68). It is assumed in this thesis, therefore, that the majority of the sand banks are marine features that developed after the land had submerged. Many certainly continue to develop, reworking material as they slowly 'wander' across the seabed. Material dredged from the Brown Bank area includes deposits and artefacts dating from the Pleistocene through to the modern period (Peeters *et al*. 2009, 24). The sand banks would not, therefore, have been evident in the Mesolithic landscape, or indeed later as islands in the Neolithic seascape (discussed briefly in Chapter 7).

Much of the dated offshore peats come from this area. The LOIS project dated a core from the area of the Dogger Bank, providing evidence for peat at a level of -31.06 m OD with a date of around 6000 cal BC. A core drilled 5 km off the Norfolk coast also recovered peat, the upper levels of which formed under intertidal conditions, dated to around 5600 cal BC at 19.89 m OD. A group of cores from the Well Bank area recovered organic deposits from between -37 to -39 m OD with dates clustering around 7050 cal BC (Shennan *et al*. 2000).

Peat beds and submerged forests with a variety of prehistoric dates have been recorded in the Norfolk, Lincolnshire, and Yorkshire intertidal zones (Hazell 2008). Cores taken as part of the LOIS project show that Holocene peats formed along the Norfolk coast from 9000 cal BC and continued to form in a number of places until 5050 cal BC. From this point marine mudflat and saltmarsh environments developed as a result of rising sea-levels (Andrews *et al*. 2000). The Fenland embayment was also studied as part of the LOIS project. This recorded the onset of marine conditions in the northern Fenland by *c*. 5900 cal BC. By around 5000 cal BC most of the eastern and north-central parts of the Fenland had been flooded and over the following millennia marine-brackish sedimentation spread landward (Brew *et al*. 2000).

Freshwater peat with evidence for overlying saltmarsh conditions has been recovered from the outer Humber estuary and indicates marine inundation there from the sixth millennium BC (Ridgway *et al*. 2000). On the inner part of the Humber Estuary at Ousefleet, freshwater peat was recorded at -12.92 to -12.85 m OD and was dated to around 7260 to 6000 cal BC. Diatoms within deposits overlying the peat layer indicate a spike in salinity, perhaps representing a temporary incursion of sea water, whilst fully marine conditions were established above this at a height of -11.20 m (Metcalfe *et al*. 2000). Rees *et al*. (2000) identified eight sediment suites based on a series of boreholes within the Humber Estuary, showing that the freshwater Basal Suite was overlain by the Newland and Butterwick suites deposited between 6050 and 5450 cal BC in brackish environments. These were overlain by marine and saltmarsh sediments of the Garthorpe Suite (Rees *et al*. 2000).

Palaeogeographical reconstructions show that the present Northumberland coastline, lying near to the isostatic hinge line (Chapter 3), is close to the Holocene coastline. The early Holocene shoreline was a few metres further east than today, Plater and Shennan (1992) suggested that the sea-level has changed by around 2.5 m. Cores taken as part of Plater and Shennan's work show that organic sedimentation at Elwick, Alnmouth and Warkworth was replaced by clastic sedimentation around 6000 cal BC, revealing a rise in relative sea-levels (Plater and Shennan 1992). As part of their study on sediment flux in the Tees Estuary, Plater *et al*. (2000) produced a sea-level curve using sea-level index points (SLIPs) (see Chapter 3 for definition) taken from intercalated peats, showing that relative sea-level change was a major control on sediment flux. The peat sequence was dated to between 6050 and 4050 cal BC (Plater *et al*. 2000).

Artefacts are regularly dredged from Area 1 providing evidence for occupation of this landscape, the origins of which go back to the barbed harpoon dredged by the Colinda in 1931 (Fig. 1.1 in Chapter 1) around the Leman and Ower Banks. Settlement activity is recorded on land on the western side of the area, for example at Star Carr on the edge of the former Lake Flixton in the Vale of Pickering (Fig. 4.1:1). This site was first excavated by Clark between 1949 and 1951 (1954) and has been the focus of small-scale excavation at various points since (*eg* Conneller and Schadla-Hall 2003). It represents a large, persistently used lakeside settlement dating to around 9000 cal BC (Dark *et al*. 2006), with evidence for substantial wooden constructions, such as a large timber platform, and a post-built structure (Conneller *et al*. 2012). Such a site could well provide an analogy for occupation around lakes in Northsealand, particularly around the Outer Silver Pit.

Mesolithic finds and sites are distributed along the coast in northeast England (Passmore and Waddington 2012), particularly between the Tees and the Tweed (Young 2007). Further landward evidence comes from the recent discovery and comprehensive excavation of an intact narrow-blade occupation site at Howick, dating to between 7970 and 7760 cal BC (Fig. 4.1:2) – a cliff top site along the present-day Northumberland shoreline (Waddington *et al*. 2003; Waddington 2007a and b).

Substantial evidence for Mesolithic activity has been recorded along the Baltic Sea coast. This is east of Area 1 and beyond the study area, and therefore a full description of all the work completed is beyond the scope of this thesis (and not shown on Fig. 4.1), but will be briefly described. In Denmark, for example, the Ertebølle sites of Tybrind Vig and Fyn provide evidence for submerged Mesolithic sites (Andersen 1985; Fischer 2004; Andersen 2011; Uldum 2011). These include intact hearths and middens, textile fragments and elaborate wooden artefacts, such as decorated paddles (Andersen 2011). Well-preserved dwellings have also been recorded on the Danish sea floor, such as Møllegabet II (dated to 5500–5000 cal BC) where some wall stakes and a bark floor were preserved (Grøn and Skaarup 2004a and b). Graves have also been recorded – an excavated example from Møllegabet was within a dugout canoe (Rieck 2003), and a double burial has recently been excavated at Tybrind Vig (Uldum 2011). Extensive patches of submerged forest were also uncovered (Fischer 2004).

Similarly, underwater surveys of the Wismar Bay, on the German Baltic coast, have identified a number of new submerged Mesolithic sites with varying degrees of preservation (and with good potential for understanding the transition to farming [Hartz *et al*. 2007]). They are primarily located around the island of Poel on a moraine ridge and up to twelve metres below sea-level (Lübke *et al*. 2011). The sites largely date to between 6800 and 5000 cal BC and were formerly located on freshwater lakefronts or riverbanks. The Jäckelberg-NNW site included a hearth surrounded by flint artefacts and a red deer bone dating to between 6600 and 6500 cal BC. Jäckelberg-Huk included two hearths and a cultural layer dated to 6400 to 6000 cal BC, sealed by a succession of mud and reed peat layers indicating rising water levels.

The Jäckelrund-Orth site was located on a small island on the edge of the Great Deep just off the Jäckelberg peninsula. Here a cultural layer containing flint and red deer artefacts and animal bones were associated with *in situ* tree stumps dating to between 5900 and 5700 cal BC (Lübke *et al*. 2011). The Jäckelberg-Nord site, comprising an outcrop of peat, is an early Ertebølle site dating to between 5400 and 5000 cal BC and (Lübke 2003; Lübke *et al*. 2011). West of Poel and below 2.5–3.5 metres of water is the well-preserved site of Timmendorf-Nordmole, which dates to the late Ertebølle period from 4500 to 4100 cal BC.

Although erosion has scoured the top of the site, finds include the remains of at least two dugout canoes, fragments of paddle, fishing harpoons in various states of production, part of an elm bow, and evidence for red deer bone working. The rich flint assemblage comprised waste flakes, trapezoids, and over 100 axes. Seals, sea birds, red deer and wild boar were hunted, however, fishing clearly made up the primary resource (Lübke 2003).

4.3 Area 2: The delta plain and Dover gorge (lower southern North Sea and Dover Strait)

This area lay immediately beyond the ice sheet and therefore was glacio-isostatically uplifted due to the forebulge effect during the last glaciation (Chapter 3). As the ice sheet retreated, the forebulge collapsed leading to accelerated subsidence in the area throughout the early and middle Holocene (Hijma and Cohen 2011).

Dominating Area 2 is the vast south flowing delta plain of the Rhine/Meuse river system on the eastern side, and the River Thames on the western, and the associated catchments, of rivers such as the River Scheldt on the eastern side and the River Yare on the western. These rivers converged in the south of Area 2, to form a single large channel referred to as the Lobourg Channel, which, in the early Holocene, flowed through the Dover gorge: a previously formed gap in the Weald-Artois chalk ridge, thereafter forming the Channel River (see Area 3 below). This represents a major fluvial system that drained much of modern southeastern Britain and northwest Europe.

As with Area 1, this area is low-lying and off the Suffolk coast are the possible remnants of intertidal flat deposits (Limpenny *et al*. 2011). This evidence suggests that rivers flowed through a predominantly waterlogged and marshy landscape, perhaps interspersed with occasional open shrub woodland. On the western side of Area 2, a large river channel, which flowed east and then meandered south off the East Anglian coast has been recorded. This is likely to be a continuation of the present-day Yare-Bure valley system (Fig. 4.7). The channel is infilled with marshland peat, two samples of which date to 10,710 to 10,280 cal BC and 7530 to 7350 cal BC (Limpenny *et al*. 2011; Hazell in prep), and can be compared to onshore peats at the Yare/Bure confluence at Great Yarmouth dated to 6600 to 6240 cal BC (Limpenny *et al*. 2011, 129). This sequence is overlain with progressively more estuarine sediments, deposited as the area was being inundated around 5970 cal BC (Limpenny *et al*. 2011, 258).

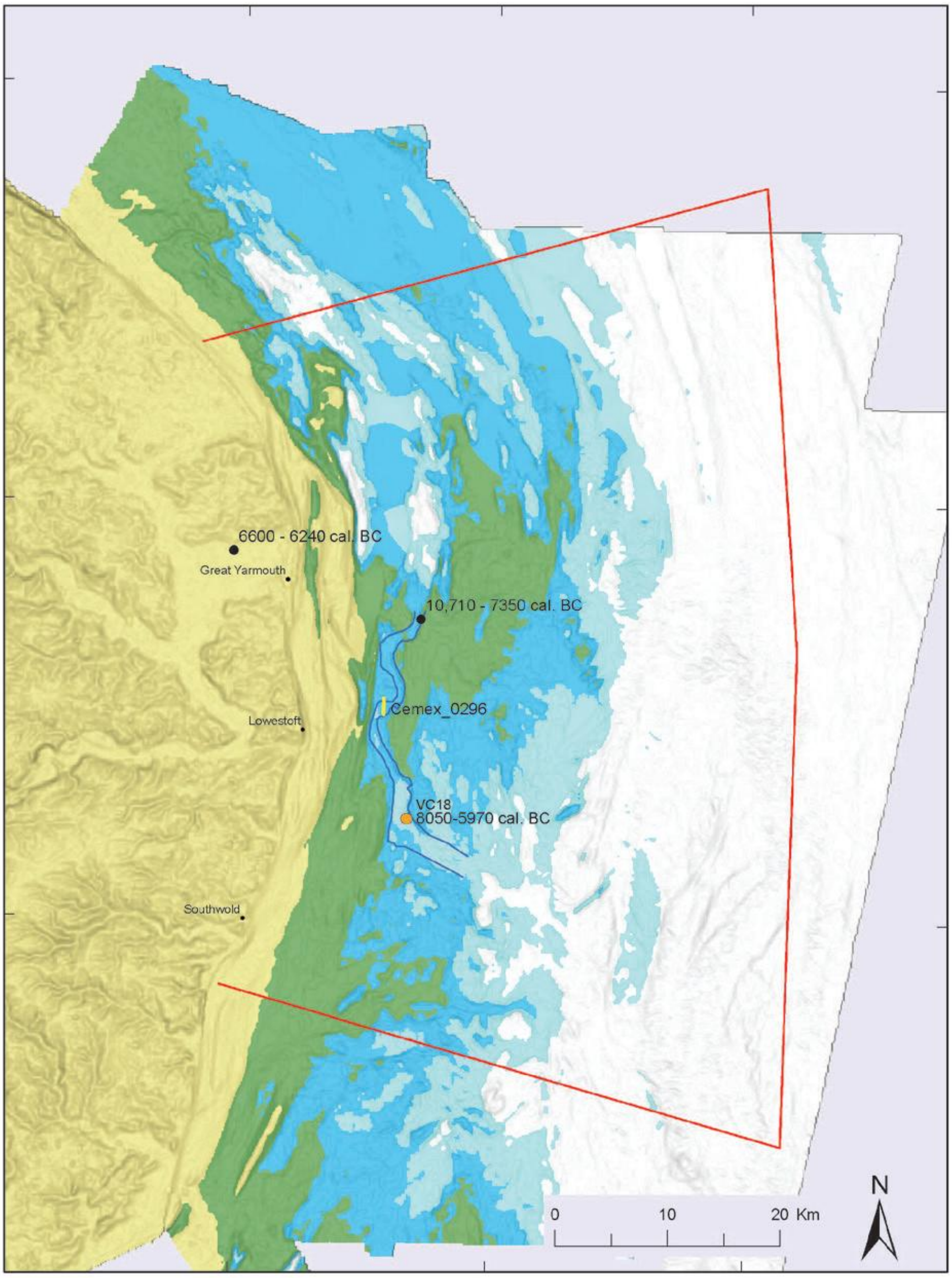


Fig. 4.7: A large Holocene channel off the East Anglian coast with sea-levels modelled at 25 m below OD and location of 14C dates marked. (From Limpenny *et al*. 2011, 131).

Further south and forming part of this large confluence, work for the Outer Thames Estuary REC has identified extensive Late Glacial and Holocene deposits infilling the main relict Thames channel and its tributaries (Fig. 4.8). Cores through the main channel indicate the presence of sands overlain by freshwater silts and peat dated to between 8500 and 8210 cal BC, and then finally sands and gravels representing final marine transgression (Dix and Sturt 2011, 111). Post-inundation deposits in this area include the Elbow Formation laid down in intertidal or subtidal conditions, and the Bligh Bank Formation, comprising the reworking of Pleistocene deposits between the Dover Strait and Southern Bight (Dix and Sturt 2011).

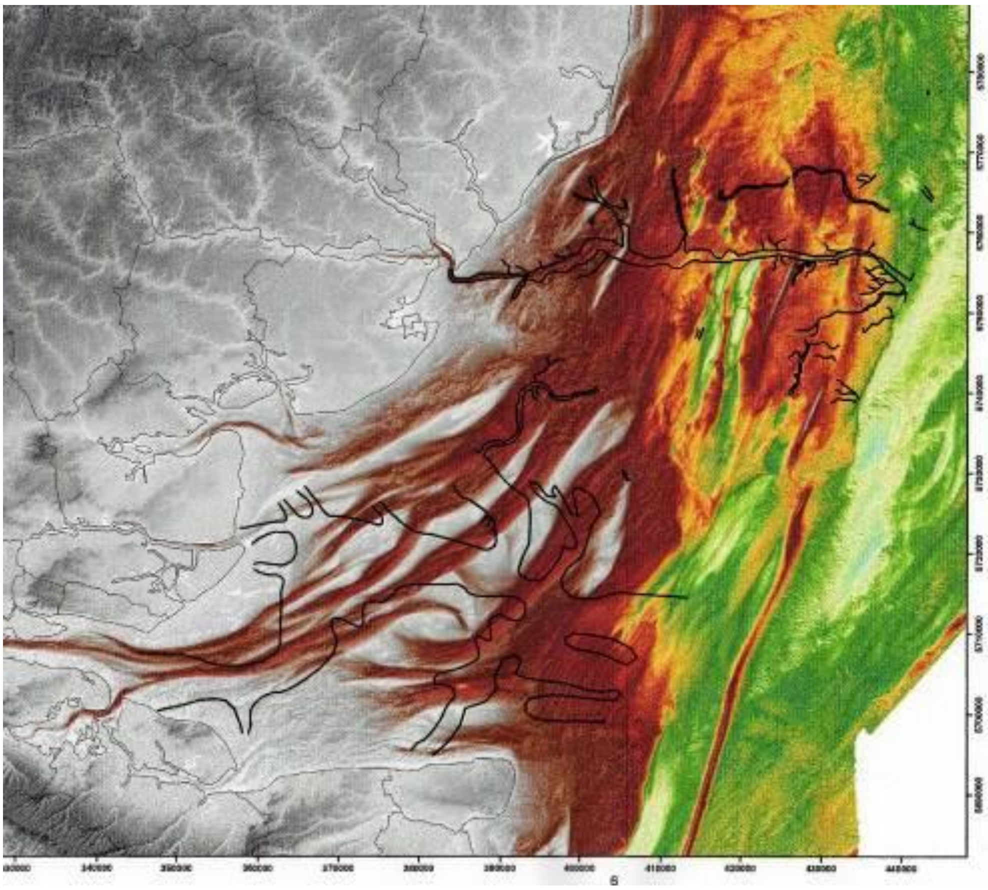


Fig. 4.8: The relic Thames and associated channels within the Outer Thames REC. (From Dix and Sturt 2011, 6).

The southern-most part of Area 2 has not been surveyed by geophysics making landscape characterisation more speculative than for elsewhere, but it is likely to have been a key region. The large (Continental-scale) south-flowing river network, which included the Meuse, the Rhine, and the Thames, converged and amalgamated here in the early Holocene to form a single large channel (the Lobourg Channel). This flowed through a gap that had formed during an earlier interglacial (Gupta *et al*. 2007) in the Weald-Artois ridge, referred to here as the Dover gorge (Fig. 4.9).

The chalk ridges (a continuation of the North and South Downs in southeast England) and the Dover gorge will have been major topographic features in the early Holocene, and one that was potentially highly attractive to animals and people. The chalk will have provided a high area overlooking the large low-lying deltaic plain to the north or the Channel River area to the south (Area 3) – a type of location apparently favoured for occupation in the Mesolithic (Waddington 2007a, 104), for example at Howick (Area 1 above), or at sites on the Channel Islands and Cotentin Peninsula (Area 3 below). Furthermore, the Weald would have continued into this area (Fig. 4.9) and, given the notable concentrations of Mesolithic activity on the Lower Greensand belt of the Weald (Rankine 1936; 1948; 1949a; 1949b), is likely to have been heavily utilised. This is an area with a suggested distinctive microlithic technology (Clark and Rankine 1939, 95–6; Jacobi 1978b; Reynier 2005). It may well be that the terrestrial evidence from the Weald was peripheral to a greater concentration of activity focussed on the banks of the Lobourg Channel as it passed through the Dover gorge.

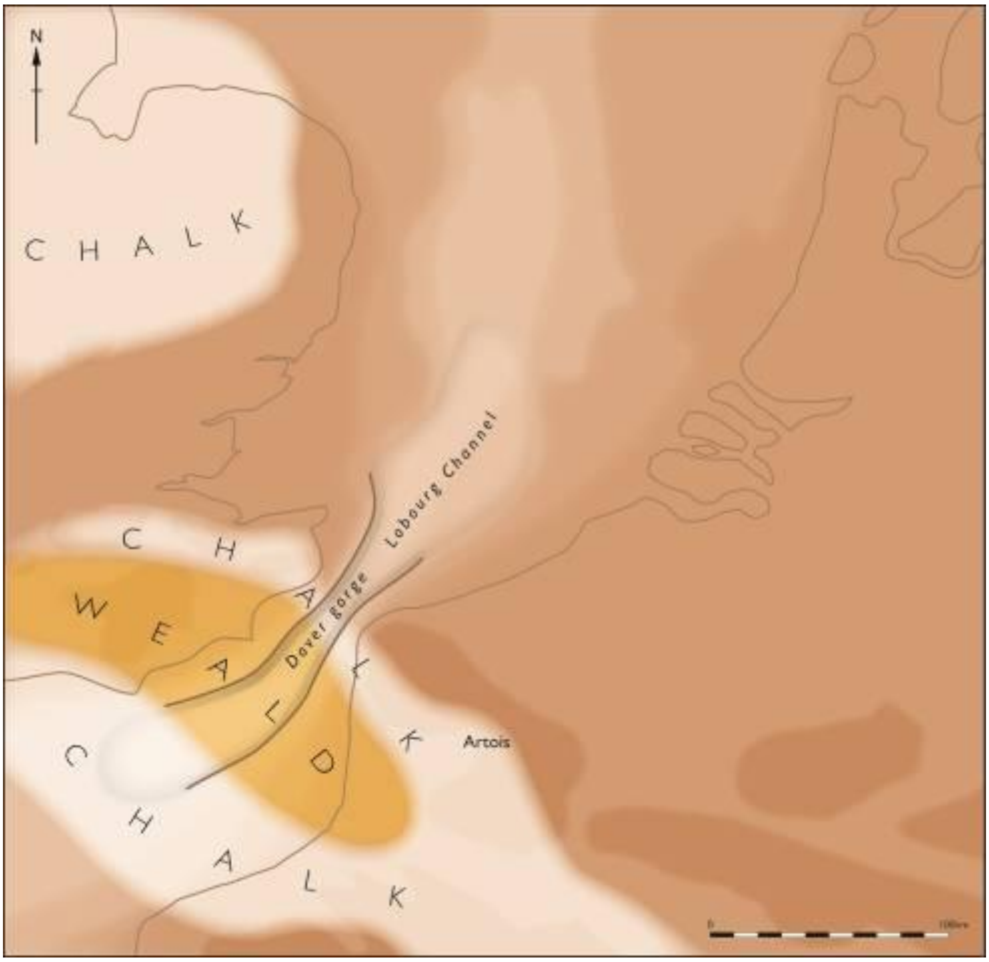


Fig. 4.9: Map showing the extent of the chalk in the Dover gorge area. (Based on information from Hijma *et al*. 2012, 31).

On the eastern side of Area 2, within the Rhine/Meuse delta, inland aeolian sand dune complexes had formed along river valleys during the Younger Dryas and early Holocene (Hijma and Cohen 2011, 1456). These would have been prominent features during the Mesolithic period. Higher terraces within this area were capped by coversand (aeolian sands formed in periglacial condition) and which contained extensive freshwater wetlands (Hijma and Cohen 2011).

As sea levels rose, the Channel/Manche was pushed north, through the Dover gorge, and by the end of the eighth millennium cal BC existed as a large embayment extending through Area 2 (Figs. 1.3 and 1.11 in Chapter

1). The evolution of the Rhine/Meuse delta during this part of the Holocene has been well-studied (Hijma and Cohen 2011). This has shown that by 7150 cal BC sea level was -24 m OD and river channels flowed through an extensive and permanently waterlogged marsh environment. Woody debris from channel fills indicates swamp forest further upstream. The period to 6550 cal BC was marked by the gradual advance of coastal and estuarine environments into the wetland zone and the replacement of fluvial channels with tidal ones (Hijma and Cohen 2011, 1464). From this point to 6050 cal BC sea-levels rose very rapidly as a result of the '8.2 kya cold event' (see Chapter 3), causing a "sudden, near-instantaneous" drowning of this environment, transforming it from a fluvial floodbasin to back-barrier basin (Hijma and Cohen 2011, 1464).

The link joining the southern North Sea and Channel/Manche may have occurred at this time. This would have affected the tidal regime by increasing the tidal range along river networks far inland (Chapter 5), and causing the rapid abandonment of some channels. The Meuse, for example, was forced into a more southerly route (Hijma and Cohen 2011). Sea-level rise continued, albeit at a slower rate. The dune complexes of the Rhine/Meuse delta became submerged, with only the larger ones remaining as islands of dry land which provided a focus for local occupation (Out 2010).

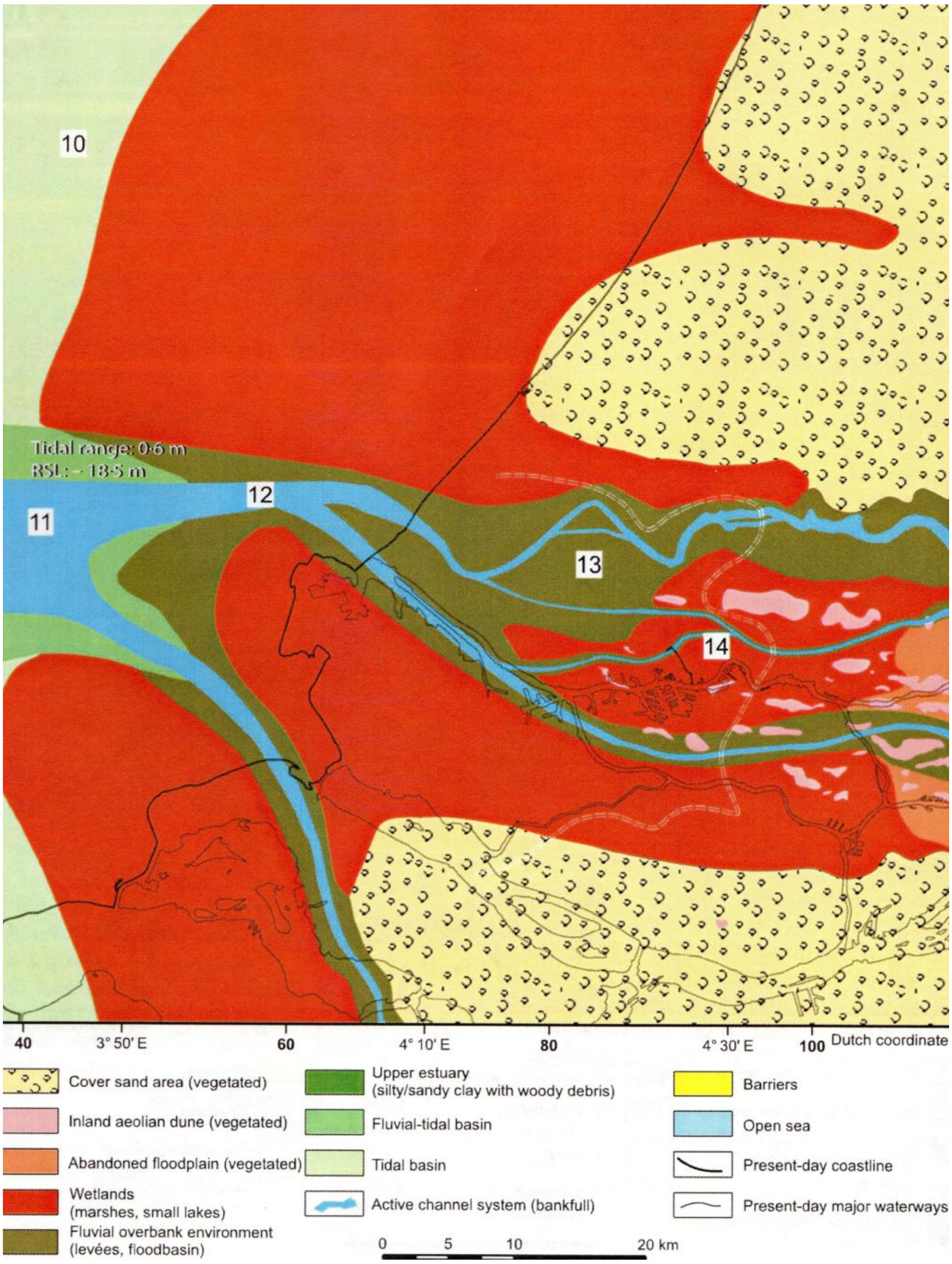


Fig. 4.10: Palaeogeography of the Rhine/Meuse River mouth at 6550 cal BC showing extensive wetlands. (From Hijma and Cohen 2011, 1465).

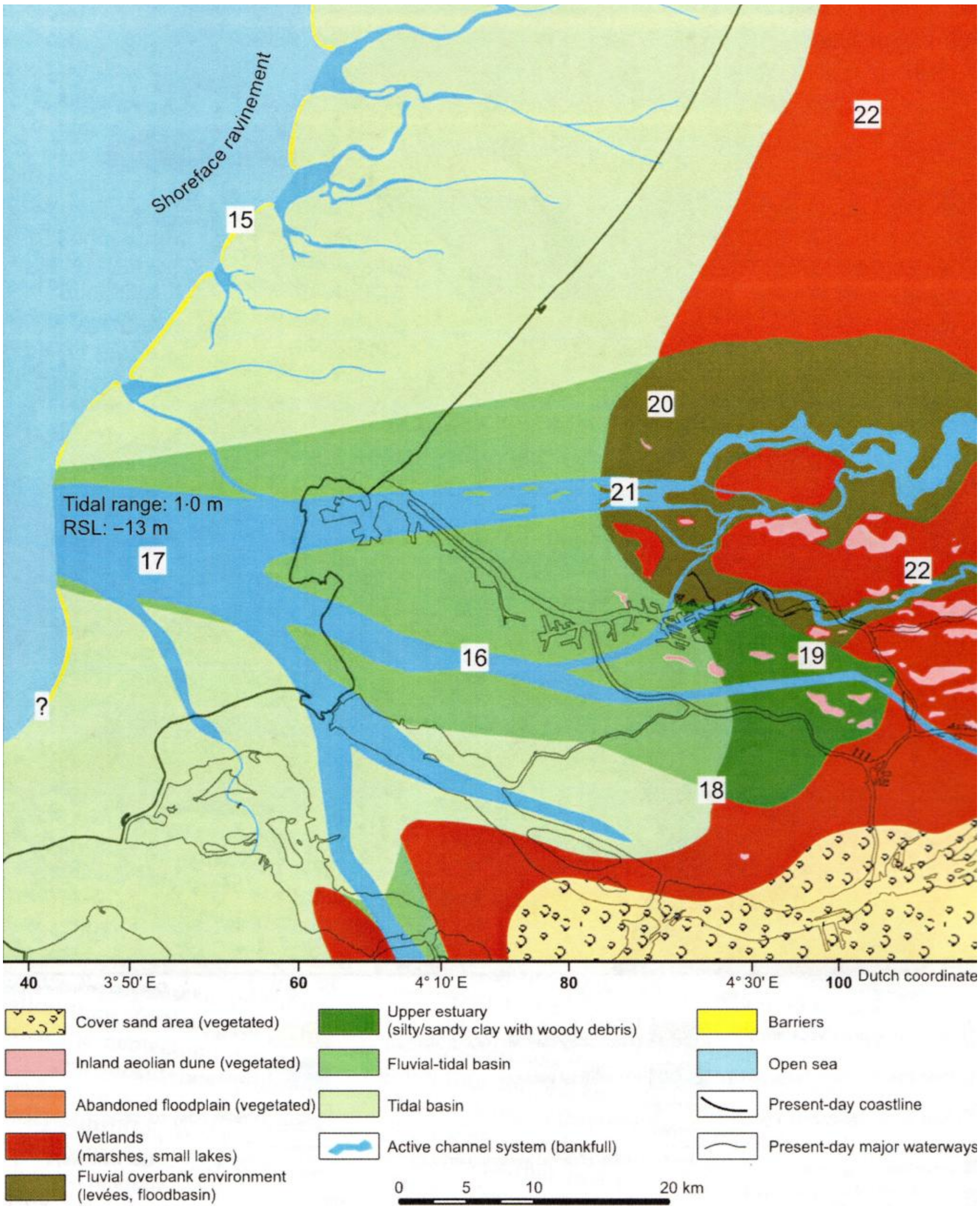


Fig. 4.11: Palaeogeography of the Rhine/Meuse River mouth at 6050 cal BC following the sea-level rise jump event and substantial loss of land. (From Hijma and Cohen 2011, 1466).

The construction of the Europoort harbour near Rotterdam (Fig. 4.1:3) in the 1970s, led to the discovery of numerous Mesolithic bone and antler barbed points, interpreted as lost hunting gear (Verhart 2004) (although see alternative interpretation in Chapter 6). Submerged sites have been excavated on the dunes in the Rhine/Meuse delta in the municipality of Hardinxveld-Giessendam, The Netherlands (Fig. 4.1:4), providing a wealth of information on settlement activity and subsistence. Discovered in 1994 and excavated in 1997/8, the De Bruin and Polderweg sites are situated on coastal dunes that were occupied from 5500 to 4500 cal BC (and therefore contemporaneous with the Early and Middle phases of the Ertebølle culture: Louwe Kooijmans 2003).

The excavations revealed the remains of dwellings, including sunken floors, a complete dugout canoe, paddles, elm bow fragments, worked antler, and a fish trap. Fish clearly represented an important resource, indicated by the presence of ten million fish bones, as were beaver and otter. A number of burials (including dog burials) were also recorded. As ground water level rose, the dunes shrunk in size and the range of tools became restricted, perhaps indicating a change in function. Finally the dunes were submerged entirely and activity ceased (Louwe Kooijmans 2003).

The Flevoland polders in the western part of The Netherlands (Fig. 4.1:5) have also provided a rich insight into Mesolithic activity on the coversands. The polders (coastal area) of the Province of Flevoland were reclaimed from the sea from the 1940s to the 1960s when the first excavations near Swifterbant uncovered Mesolithic and Early Neolithic sites. However, it is only relatively recently, with increased construction activity from the mid 1990s onwards, that their archaeological potential been fully realised, with excavations such as Schokland-P14, Emmeloord-J97, Urk-E4 and Hoge Vaart-A27. At these sites well-preserved *in situ* Mesolithic and Neolithic sites comprising lithic and bone artefacts, burials, structural remains such as fish weirs, and submerged forests, have been discovered. These are sometimes many metres below the modern ground surface (Peeters 2006; 2007; Maarleveld and Peeters 2004).

The excellent palaeoecological data from these sites has yielded much information about the dynamics of sea-level rise and settlement activity. At the Hoge Vaart-A27 site, for example, the archaeological evidence shows that at around 6600 cal BC a sand ridge was covered by a lime-dominated forest, while the lower-lying area, in which a stream meandered, was swampy. By the middle to early sixth millennium the forest had developed to one dominated by oak and lime. Hearths testify to human activity through both periods. By the beginning of the fifth millennium tidal activity had begun to affect the sand ridge with the gully dominated by reed swamp. Oak woodland dominated the ridge, but by the middle of the fifth millennium peat, recorded ever-further up the slope, indicates that it was being inundated. By this time deep hearth pits were no longer used, and deliberate and perhaps votive deposits of struck flint (Chapter 6), and both cremated and uncremated bones, were recorded (Peeters 2006; 2007; dates calibrated from Peeters 2007 using OxCal 4.1).

Friesland, an area covered by boulder clay of the Drente Formation on the Frisian-Drentian plateau immediately north of Flevoland, would have undergone significant inundation in the Mesolithic period (unfortunately

Fokkens [1998] study does not cover the Mesolithic period). Inundation of this area led to the Frisian Islands being cut off sometime after 6000 cal BC (Behre 2007).

South of the Dutch border in northwest Belgium, and sharing the same coversands geology, is Sandy Flanders. This is an area, like its Dutch counterpart, rich in prehistoric sites. The topography is characterised by numerous low coversand ridges. These are dunes formed primarily by sediments blown by northwestern winds from the bottom of the southern North Sea plain during the Late Glacial period. To the south, tertiary cuestas provided areas of higher relief, as well a source of flint. The river system was dominated by the Scheldt, which formed a tributary of the Rhine/Meuse delta (Crombé *et al*. 2011).

The construction of docks around the port of Antwerp in the River Scheldt valley in the last ten years, and intensive and systematic fieldwalking in the last twenty-five years, has led to the discovery of well-preserved Final Palaeolithic (*Federmesser*) and Mesolithic sites. This includes a large early Mesolithic activity area discovered on one of the sand ridges (the Great Ridge) at Verrebroek (Crombé *et al*. 2002; Crombé *et al*. 2011). Excavations at Verrebroek indicate that it was revisited over a number of centuries (Crombé *et al*. 2011), with evidence for hearths, pits and flint scatters (Verhart 2008).

Overall, the evidence suggests that Sandy Flanders was intensively occupied during the Late Glacial and early Mesolithic. Early Mesolithic activity was relatively small and seasonal, perhaps reflecting mobile groups, and focussed on the banks of river systems. By the Final Mesolithic, activity appears to have been more prolonged with reduced mobility and a greater focus on the lower, wetter areas. Crombé *et al*. (2011) suggest this may be due to the appearance of closed canopy forests, unfavourable for large game, forcing people towards forest edges and wetlands, which were themselves expanding as a result of sea-level rise. Coastal areas, however, were finally inundated at a relatively late stage, between 4550 and 4050 cal BC (Crombé *et al*. 2002; Crombé 2006; Crombé *et al*. 2011).

Discoveries of Holocene faunal remains, such as red deer, elk, and boar, as well as Mesolithic artefacts, such as modified red deer antler, by fishermen around the Brown Bank area from the late 1960s lay further testament to the use of this offshore area during these periods (Glimerveen *et al*. 2004; Kolfschoten and Essen 2004; Chapter 7).

Holocene sea-level rise in southeast England has been intensively studied; however the majority of sites date to the mid and later Holocene. The available sea-level reconstructions highlight the considerable variations between sites, reflecting the importance of local processes. The sediments recorded are complicated and despite the work so far undertaken the picture is far from clear. Only a handful of SLIPs have been collected from the Essex coastline presenting an incomplete picture. Pioneering archaeological work in intertidal zones was carried out by Wilkinson and Murphy in 1986 in the Blackwater and Crouch estuaries of the Essex coast (Fig. 4.1). This has demonstrated the potential these areas have for landscape reconstruction and for understanding Holocene sea-level changes. Extensive Mesolithic flint scatters were recorded in both estuaries, providing evidence for settlements alongside freshwater streams, which may have flowed through woodland. By the onset of the Neolithic, the adjacent areas had gradually developed into estuaries. The sequence from the Crouch estuary revealed deposits containing Mesolithic and Neolithic flint tools overlain by clays containing brackish/marine diatoms indicating inundation caused by sea-level rise. This was followed by a marine regression and the clays graded into layers of freshwater peat. This in turn merged into peat formed in the later Neolithic period under oak-alder fen woodland, and which included preserved trees and tree boles (Wilkinson and Murphy 1986). Long (1995) re-examined the evidence from these sites and produced a sea-level curve based on radiocarbon dates from the peat deposits.

Devoy (1977; 1979) produced the first comprehensive study of the lower Thames estuary, based on a stretch of the river that included sites such as Tilbury, Crossness, Stone Marsh and Dartford Tunnel, Littlebrook, Broadness Marsh and the Isle of Grain. He identified five transgressive and four regressive phases, and suggested that sea-level may have risen by 15 m between 9550 BC and 4900 cal BC, although levels fluctuated during this period. Critical re-examinations of the detail of this work have followed, questioning Devoy's interpretations. It is now known that peat compaction, erosion and shrinkage played a much larger role than previously thought leading to under-estimation of sea-level heights (Long 1991).

Long (1991; 1992) undertook tendency analysis in the East Kent fens to identify local trends and changes. This study showed that sea-level fluctuated greatly in the short-term against a background of generally rising sea-levels. Freshwater conditions were recorded between *c*. 5650 cal BC and *c*. 5000 cal BC, followed by marine conditions between *c*. 4350 and *c*.

3950 cal BC (Long 1992, 195). Conditions continued to fluctuate into the late Holocene.

In the Romney Marsh area (Fig. 4.1), organic silts formed from around 10,000 to around 9200 cal BC, at -8.5 m OD (Waller *et al*. 1988). West of this, work at Langney Point near Eastbourne revealed a sequence of clays and sand at a depth of -29.10 m OD and peat at -24.82 m to 24.70 m OD, the top of which is dated to 8195–7600 BC (Jennings and Smyth 1987; dates calibrated in Waller and Long 2003). However, Jennings suggested that the sediments recorded may not be related to changes in sea-level at all since the site may have been protected by a natural barrier, such as a spit. A similar sequence has been indicated for Rye, nearby, where sandier sediments, dated to 5850 cal BC, may indicate an increase in tide range following greater connection between the North Sea and Channel/Manche (Waller and Long 2003).

Numerous sea-level curves have been produced for The Netherlands (for example Jelgersma 1961; Kiden 1995). Jelgersma (1961) showed that sea-level curves from the south western Netherlands diverged from those collected from the western and northern part of the country. This was attributed to a higher coastal tidal range and a smaller amount of tectonic subsidence. Although van de Plassche (1982) has suggested that these sea-level curves are unreliable. Kiden (1995) revaluated the evidence with new radiocarbon dates from basal peats in Zeeland in the south western Netherlands and the lower part of the River Scheldt in northern Belgium.

Further south, Denys and Baeteman (1995) used thirty-eight SLIPs from basal peats along the Belgium coast to produce age-depth reconstructions of the Holocene relative sea-level rise. This study assumed a mean compaction of 50% for all cores taken, which may have led to either overestimations or underestimations. The results suggested that sea-level rise could be estimated at around 7 m/kyr, at which point the rise slowed to around 2.5 m/kyr (Denys & Baeteman 1995, 16). This trend differs from that of the neighbouring Netherlands – with the Belgian RSL higher than the Dutch in the early part of the sequence.

4.4 Area 3: The Channel River (eastern Channel/Manche)

Dominating the early Holocene landscape of Area 3 was the east-west Channel River (sometimes also referred to as the Northern Palaeovalley). This was a substantial and probably braided westward flowing river some 8–20 km wide. It continued the Lobourg Channel from the Dover gorge and subsequently incorporated tributaries with sources in England, such as the Hampshire Avon, Stour, Test, Arun, Adur and Ouse, and France, such as the Authie, Somme and Seine.

Structurally the eastern Channel/Manche falls within the Wessex Basin (James *et al*. 2010; Arnott *et al*. 2011), which also includes much of the terrestrial land in southern England. Upper Cretaceous chalk is extensive across Area 3 and is exposed in large tracts across the seabed (Fig. 4.12). Swathes of Lower Greensand are also evident across the area, particularly around the Isle of Wight. Other softer deposits, such as the Tertiary rocks of the Hampshire-Dieppe Basin, result in differential erosion and the creation of lower areas. The Devensian ice sheet did not extend to this region, although soliflucted deposits, ice wedge hollows and fissures, periglacial stripes, and small mounds formed of redeposited chalky gravel from glacial outwash (naleds) will have helped shape the subsequent early Holocene landscape (James *et al*. 2010; Arnott *et al*. 2011). Mounds such as these may well have provided vantage points for hunters, as indicated by similar at the terrestrial site at Cranborne Chase (Green 2000, 27–8). The gravels exposed by such processes could also be exploited for use, such as for pot boilers (Field 2008, 36 in relation to the naleds on the Wessex chalkland).

The chalk and greensand within this area probably had similar soils to those found on land today. The chalk areas were not necessarily wooded – recent work on terrestrial chalk upland in southern Britain suggests that it was likely to have been open throughout this period (French & Lewis 2005).

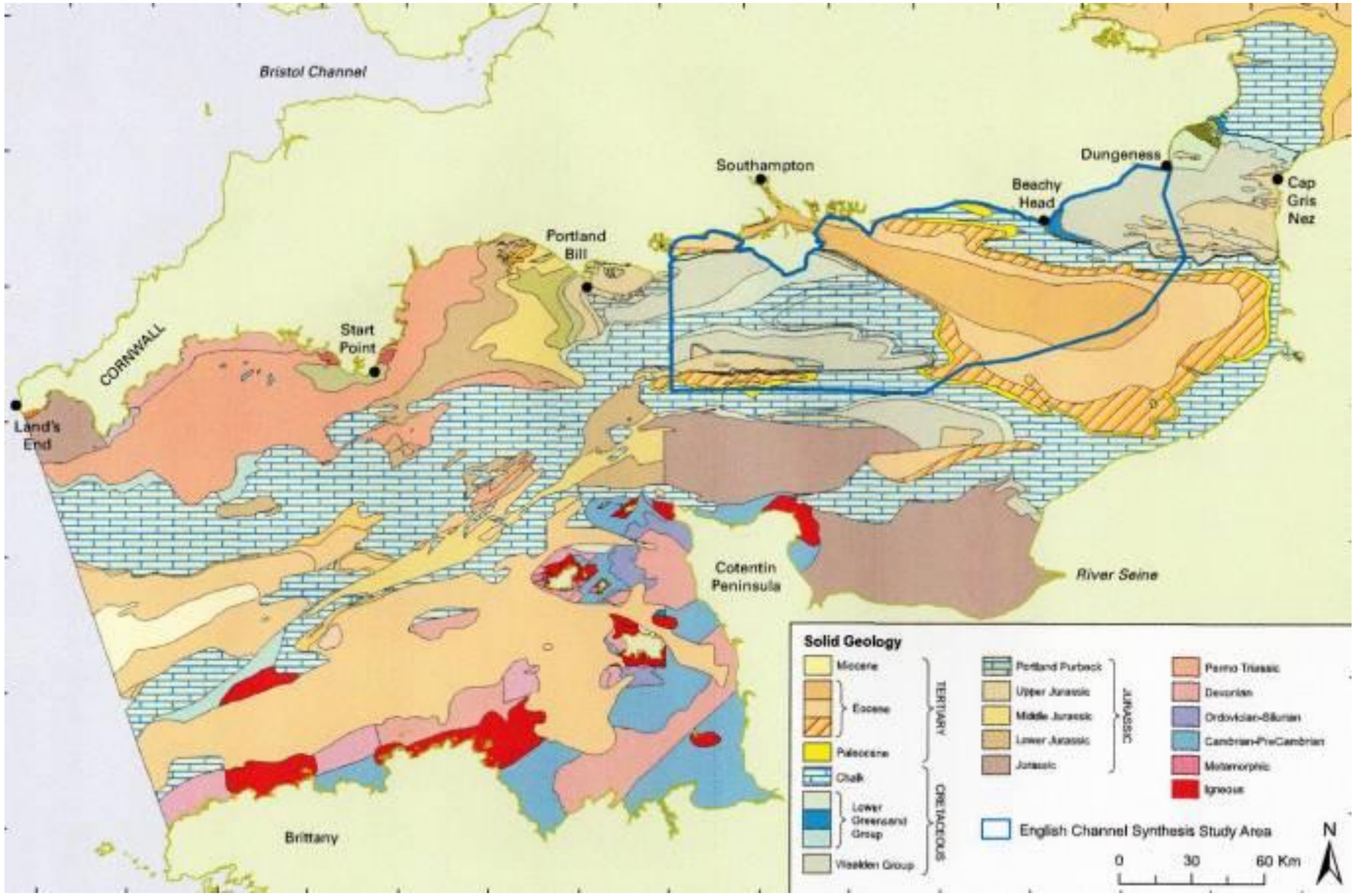


Fig. 4.12: Offshore solid geology in the Channel/Manche. (From James *et al*. 2011, 6)

The Channel River had a number of tributaries, some of which were flanked by varying numbers of gravel terraces laid down successively in earlier periods. These are traceable beneath the sea and associated now with Palaeolithic finds (Bates *et al*. 2007a and b). A submerged length of the River Arun, dating from the Mesolithic period, has been particularly well studied through Wessex Archaeology's MALSF-funded Seabed Prehistory project. Data from vibrocores showed evidence of an aquatic fen next to slow moving water with local saltmarsh. Pollen indicates that a birch and pine woodland fringed a freshwater wetland and reedswamp during the early Mesolithic period (Wessex Archaeology 2008a, b and c); and this is a likely scenario for much of the area at this time.

Bathymetric surveys reveal a number of scarps, ridges and high points in the Channel/Manche (Fig. 4.13) where rock outcrops are exposed on the seabed. These include the channel margins and bars of the Channel River, and a series of ridges and highs, particularly north of the Channel River around Selsey Bill, west of the submerged length of the Arun, and south and east of Beachy Head. It also includes a now submerged ridge extending from Hengistbury Head (Hengistbury Ridge) to the Isle of Wight, which will have formed a striking chalk escarpment (James *et al*. 2011).

Another ridge, the 10 km-wide chalk Monocline Rampart Enclosure, extends for about 25 km on the south coast of the Isle of Wight would also have formed an obvious topographical marker during the Mesolithic period (Fig. 4.13). Immediately north of this is St Catherine's Deep, a narrow channel cutting more than 60 m into the underlying Greensand (James *et al*. 2010; 2011); together these two will have formed dramatic features of the

Mesolithic landscape. The most prominent negative feature in Area 3 is the Hurd Deep, a 15 km long narrow linear north-east to south-west depression. It lies just north of the Channel Islands and would have formed a lake during the Mesolithic period. Another deep is Nab Hole, a 3 x 3 km depression to the east of the Isle of Wight.

The Channel/Manche existed as an embayment in the early part of the Holocene, advancing along the Channel River (Figs. 1.3, 1.9 and 1.10 in Chapter 1). At some stage in the eighth millennium cal BC it flooded the Dover gorge creating the Dover Strait. As sea levels rose, ridges of higher areas were breached and land cut off forming islands, the most prominent of which were the Channel Islands on the southern side, and the Isle of Wight on the northern. As Field (2008, 89) notes, the lower reaches of the Solent would have become increasingly lagoon-like and attractive to Mesolithic communities, providing an “ideal haven as the island provided shelter from both south westerly wind and the incoming North Atlantic Drift”.

Although not as extensive as those of the southern North Sea, sand banks are evident along the seabed of the Channel/Manche. Again, these probably formed following inundation and therefore would not have been features of the Mesolithic world.

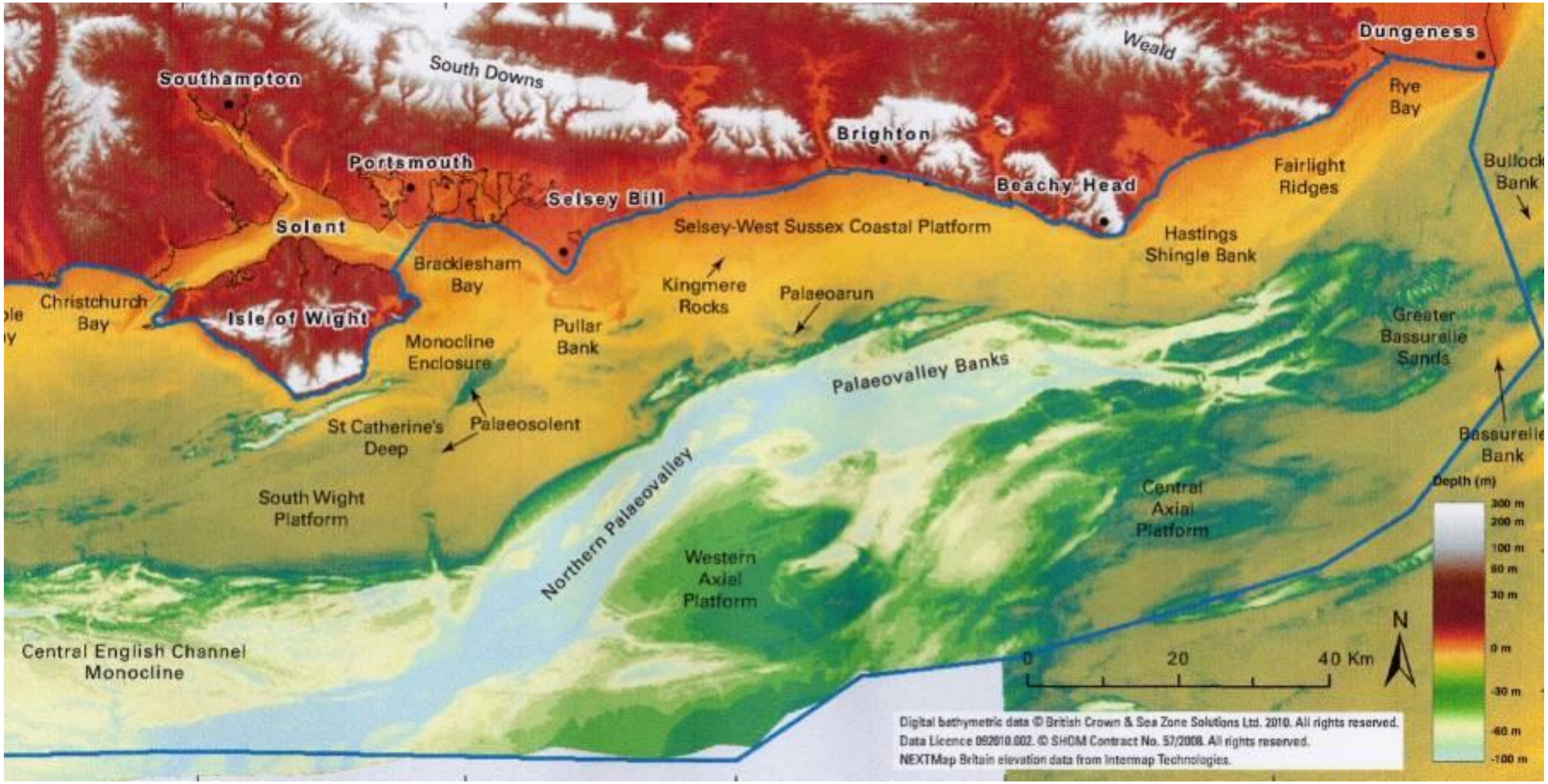


Fig. 4.13: Physical features and named localities in the South Coast REC study area. (From James *et al*. 2011, 42)

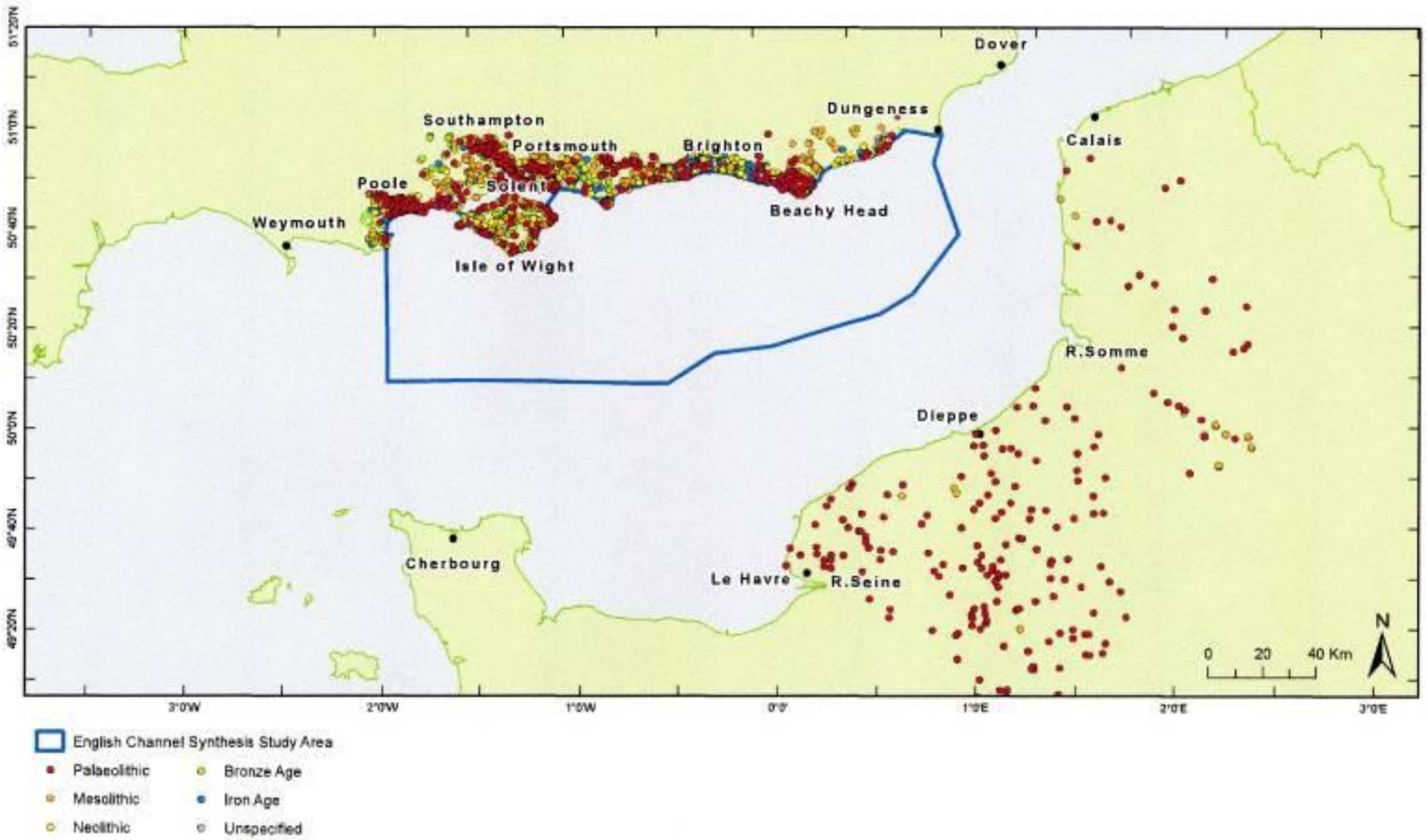


Fig. 4.14: Prehistoric sites on the English and French coasts. (From James *et al*. 2011, 124)

Evidence for Mesolithic activity has been forthcoming from along the Channel/Manche margins, the areas that are today southern England and the coasts of Brittany, Normandy, Picardy and Pas-de-Calais (Fig. 4.14). Palmer identified 778 Mesolithic sites along the south coast of Britain (1977), arguing for the presence of a 'coastal community'. More recently Field (2008, chapter 3) has provided a comprehensive review of the Mesolithic evidence within the Solent basin.

Numerous finds have been trawled from the Solent, the waterway that separates the Isle of Wight from mainland Britain. This hints at the potential the area has for preserved prehistoric landscapes. Within the Solent, Southampton Water provides evidence for pre-Holocene sediments. Flintwork is common from Christchurch Harbour, including the early Mesolithic site of Hengistbury Head (Fig. 4.1:6; Barton 1992), and from the coast between there and Poole. Unfortunately associated environmental work has not been undertaken. The Isle of Portland has seen considerable work, such as the sites of Culver Well and Portland I (Palmer 1977; 1989), where Portland chert was exploited.

The 1990s saw a number of surveys that attempted to realise the potential of the submerged landscape in this area. The Wootton-Quarr Survey, for example, along the north east coast of the Isle of Wight, recovered finds dating from the Mesolithic to the post-medieval period, following exposure due to erosion (Loader *et al*. 1997).

A similar survey was carried out at Langstone Harbour. This is a large, shallow, marine inlet between Portsea Island (Portsmouth) and Hayling Island on the Solent coast of Hampshire (Fig. 4.1:7). Initiated in

1993, this four-year survey examined the underwater zone alongside the exposed terrestrial landscape of the tidal basin. The project linked the two traditionally separate pieces of fieldwork together and successfully demonstrated the presence of deep Holocene sequences, submerged forests and late Mesolithic artefacts, as well as later structures and artefacts (Allen and Gardiner 2000).

The late Mesolithic landscape of Langstone Harbour was a lowland basin set well inland. It was dominated by two deep ravines that could have provided access from the coast to the South Downs. Through these braided and meandering freshwater streams flowed. The dry-land areas supported elements of a mixed oak woodland, whilst in the valleys open grass and sedge with freshwater fen and alder carr existed (Allen and Gardiner 2000). This rich and diverse landscape would have been attractive to hunter fisher gatherers, and the lithic evidence suggests that river gravels were being exploited from time to time for tool manufacture (Allen and Gardiner 2000).

Fig. 4.15: Aerial view of Langstone Harbour (left) and neighbouring Chichester Harbour showing the dendritic drainage pattern. (From James *et al*. 2011, 30)

In 1997, erosion around the coast of the Isle of Wight led to the formulation of a project by the Hampshire & Wight Trust for Maritime Archaeology (HWTMA) to assess deposits at the base of a submerged cliff at Bouldnor on the northwestern coast of the Isle of Wight (Fig. 4.1:8). This project monitored and recorded erosion of deposits and subsequently, following the discovery of cultural material, led to targeted excavation in 2003. Tree stumps (primarily oak) were recorded at the base of the sequence, the root of one at -11.3 m OD providing a date of between 6615–6395 cal BC. Finds recovered from the site include worked and burnt flint, a range of worked wood from a small peg to large tangentially split oak, chippings representing woodworking debris, and prepared fibres, possibly for use as cord, as well as charcoal (Momber *et al*. 2011).

Overlying the sequence were peat outcrops, at -4.1 m and -5.1 m OD, and which the latest were dated to 4525–4330 cal BC and 4920–4535 cal BC, argued to provide a calibrated marker for the relative positions of Holocene sea levels (Momber 2004; Momber *et al*. 2011). In support of this, Scaife (in Momber 2011, chapter 8) suggests that the peat formed as a result of sea-level rise triggering increased wetness. This resulted in the ponding-back of river systems and higher ground water tables and thus bringing about the establishment of extensive carr woodland. The peat also provided evidence for a short period of transition from this low-lying marsh to mudflat, saltmarsh and then fully marine conditions.

To the above it is possible to add evidence of small-scale scatters of Mesolithic material recovered from across the low-lying coastal areas of Hampshire (Bradley and Hooper 1975; Draper 1968), and Sussex (Pitts 1980; Jacobi 1978b; Palmer 1977; Wymer 1977).

Developer-funded work has led to an increased focus on the Mesolithic of northern France, particularly within the Somme and Picardy area (Ducrocq 2001; Ducrocq *et al*. 2008). The Seine and Haute-Normandie (Souffi 2004; 2008), north Cotentin (Ghesquière *et al*. 2000), and Brittany (Marchand 2005; 2007) have also seen recent work (Ghesquière & Marchand 2010). These sites testify to Mesolithic activity along river valleys from the early to late Mesolithic (Conneller *et al*. forthcoming).

Sea-levels have been studied at a variety of locations along the north French, Picardy, and Normandy coastlines, although reliably dated sea-level index points are rare. As with elsewhere in the Channel/Manche, considerable variation is recorded between sites and inconsistencies are common place. Mariette (1971) studied Holocene sea-levels along the northern French coastline, producing a broad-brush reconstruction based on freshwater peat layers at archaeological sites. This showed a rapid rise in sea-level during the early Holocene, followed by a slowing down period before reaching present levels. Sommé *et al*. (1994) took a deep core at Watten, south of Dunkerque. This showed that the sea-level was -15 m NGF (Nivellement Generale Francais – the French equivalent of Ordnance Datum) at around 6000 cal BC (dates calibrated using OxCal 4.1). Estuarine conditions followed and a shingle barrier formed producing fine sand layers inter-bedded with peat.

The Picardy coastline around the mouth of the River Somme saw some early studies. Agache *et al*. (1963), for example, used stratigraphic and archaeological data to determine patterns of relative sea-level change. Their reconstruction showed that sea-levels rose slowly between around 8250 cal BC and 6000 cal BC, followed by a series of short regressions and transgressions. Verger used marsh sediment and vegetation chronology as the primary indicators to provide a sea-level history of the Picardy coastline. This suggested that in the early Holocene sea-levels were 30 m below the present day, rising to -12 m by around 6400 cal BC (Verger 1968) (dates calibrated using OxCal 4.1). Despite studies by Ters *et al*. (1980) and Sommé *et al*. (1994; Sommé 1998) along the Picardy coast and in the Somme estuary, no attempt has been made to produce a general sea-level curve for this area. An early study of the Normandy coastline did however identify a sea-level of -9.5 m NGF at 6500 cal BC (Elhai 1963) (Elhai 1963) (dates calibrated using OxCal 4.1).

Lambeck modelled the available information from Picardy, Normandy, Brittany, and the Vendee in 1997, showing that sea-level changes were far from uniform, but broadly indicative of a rapid rise in the early Holocene. Lambeck suggests that the lack of uniformity is due to the isostatic response to the melting of the Fennoscandian ice sheet (Lambeck 1997).

Located south of the Channel River and west of France within the Channel/Manche, the Channel Islands represent an interesting study area because they would have formed land-locked elevated areas within the submerging plain during the early Holocene. As the coastline encroached they became part of the coast of mainland France before reduction to islands. It has been proposed therefore that Mesolithic sites on the Channel Islands have the potential to reflect responses to this changing environment (Conneller *et al*. forthcoming; Bukach 2004; Patton 1993). Furthermore, the extensive, low gradient coastal zone around parts of the Channel Islands mean that a slight sea-level rise would have resulted in the inundation of large areas, amplifying the impact.

Studies of Holocene sea-level rise on Jersey were first attempted by Godwin and Godwin, who examined the pollen in peat samples from St. Helier Harbour. This showed a change from a mainly dry terrestrial deciduous forest, dominated by oak and hazel, to alder. The latter is indicative of the wetter conditions resulting from a marine transgression which eventually led to the submergence of the coastal plain (Godwin and Godwin 1952).

This work was followed by Jones *et al*. (1987), who examined deposits at several locations. These included intercalated sands, clays and peats at Le Port in St. Ouen's Bay; an extensive wetland at Grouville Marsh behind the Royal Bay of Grouville; organic clays and peats at Le Marais de Saint Pierre (Goose Green Marsh), a valley-mouth just behind St. Aubin's Bay; and peats and silty clays at New Street in the centre of the St. Helier Basin. They showed the general trend towards wetter conditions followed by submergence. However, they highlighted the regional variation of sea-level rise in Jersey with movement occurring earlier on the west coast (the occurrence of an alder fen around 6000 cal BC at St. Ouen's Bay), than the east coast (brackish and saline conditions developing from around 5000 cal BC at Grouville Marsh), and with a markedly different sedimentation on the east side (dates calibrated using OxCal 4.1).

The good potential of intertidal deposits to provide insights into the nature of sea-level rise in the early Holocene on the Channel Islands has not been matched by good quality archaeological sites. Evidence for Mesolithic activity on Jersey, Guernsey and Alderney has mostly come from unsystematic surface collections of flint assemblages, usually mixed with later material. The first assemblage was recorded by Kendrick (1928) on Guernsey and subsequently on Jersey by Hawkes (1937). Scatters are now known from: Le Col de la Rocque, Le Catel de Rozel, Le Canal de Squez and Grosnez Hurel on Jersey; Creve Coeur and La Corbiere on Guernsey; and L'Emauve and Les Pourciaux/Mannez on Alderney (Patton 1993). A few Mesolithic lithics have been recovered from Neolithic sites, *eg* Les Fouillages (Sebire 2005).

Two sites have, however, recently been excavated: Lihou on Guernsey, and at Canal du Squez on Jersey. Coastal erosion led to the discovery of a stratified site on the tidal islet of Lihou, off the west coast of Guernsey. The relatively large and undisturbed flint assemblage from this site is associated with a possible stone-built hearth, and a radiocarbon date from charred hazel nutshells suggests this activity occurred between 7497–7192 cal BC (Conneller *et al*. forthcoming; Sebire 2005; Sebire and Renouf 2010). Located in a shallow valley in northwest Jersey, small-scale excavations at Le Canal du Squez have revealed lithic artefacts indicating a date of between 7150 and 6750 cal BC based on analogy with French sites (Conneller *et al*. forthcoming).

The Channel Islands would have provided an important high area overlooking the inundating coastal plain, and it is perhaps no coincidence that sites tend to be located on the top of sea cliffs (Conneller *et al*. forthcoming). This is a similar locale to those located on the Cotentin Peninsula (Ghesquière *et al*. 2000), which also facing the coastal plain, suggesting that this was the focus of interest (Conneller *et al*. forthcoming).

West of Area 3 and beyond the study area, sea-level histories for the southwest of England has been reconstructed from the Bristol Channel (Heyworth and Kidson 1982), Severn Estuary (Scaife and Long 1995) and the Somerset levels (Haslett *et al*. 1998). Information from the latter has been used to construct a sea-level curve for the Somerset levels, suggesting that there was a very rapid rise in relative sea-level in the early Holocene.

Lying between Wales and England and flowing into the Bristol Channel, the Severn Estuary is a major estuarine environment, well-known for its extremely large tidal range and extensive intertidal mud-flats. Scaife and Long (1995) compared the sea-level history of Caldicot Pil in the Severn Estuary to the Bristol Channel, suggesting that there was a rapid rise throughout the early to mid Holocene. There were also oscillations, which they attributed to varying sedimentation rates, tidal variations and the action of coastal barriers.

Numerous prehistoric sites have been recorded from the Severn Estuary, from the Mesolithic to the Iron Age, with excellent organic preservation (Bell 2007). The Mesolithic sequence from two areas in the Severn Estuary, Goldcliff East and Redwick, formed the focus of research by the University of Reading from 2001. The sites provide evidence for a submerged oak-dominated forest dated to around 5800 cal BC. Charring on some of the tree stumps has been interpreted by the excavator as evidence for extensive burning of coastal edge woodland (Bell 2006). A variety of activities were recorded from Goldcliff at this time, including animal butchery and cooking. Sea-levels continued to rise from 5700 cal BC, with evidence for a rapid rise between 5600 and 4500 cal BC indicated by banded sands and silts. Activity continued at Goldcliff East during this period as indicated by numerous human (men, women and children), and animal footprints. Other activities attested by archaeology included flint knapping, fishing and possibly the processing and drying of fish (as well as defecating). The deposition of banded silty sands led to a reduction in marine influence causing peat growth. This was followed by the development of oak woodland around 4300 cal BC, and in turn by a raised bog at 3800 cal BC. The area was inundated by estuarine sediments around 1300 cal BC (Bell 2006; 2007).

Further south, sea-level index points (SLIPs) (see Chapter 3 for definition) have been collected from the Devon and Cornwall Channel coast (Shennan & Horton 2002; Massey *et al*. 2008). Shennan and Horton (2002) used four SLIPs in their analysis to suggest that the southwest of England had the greatest rate of subsidence in the country – 1.2 mm per year. Although Waller and Long (2003), using almost the same dataset, suggested that the southeast of England may have subsided relative to the southwest. More recently Massey *et al*. (2008) identified fifteen new SLIPs revealing that there has been an overall rise in RSL of 21 +/-4 m since *c*. 7050 cal. BC, reducing to a rise of 8 +/-1 m from *c*. 5050 cal. BC.

The Isles of Scilly are located 45 km off the southwest coast of Cornwall and, as with the Channel Islands, developed as islands during the early Holocene. Between 1989 and 1993 a small-scale recording and sampling programme at three sites on the Isles of Scilly (Par Beach on St Martin's; Crab's Ledge on Tresco; and Porth Mellon on St Mary's) revealed the excellent palaeoenvironmental potential of the area's intertidal peat deposits, with radiocarbon dates ranging from the late Mesolithic to the medieval period (Ratcliffe and Straker 1997). Other areas containing intertidal peat have also been observed around the Isles, mostly seen as a result of erosion but also during coastal protection schemes, an RCHME survey in 1996/7 (Fulford *et al*. 1997), and recently as part of the Rapid Coastal Zone Assessment for the Isles of Scilly. Monitoring has continued as part of the 'Islands in a common sea' and 'Lyonesse' projects; the latter funded by English Heritage (Johns *et al*. 2009). With a growing corpus of evidence for Mesolithic activity in Scilly (Dennis *et al*. 2013), these projects are re-assessing the rate of sea level change there. Work has included surveying inter-tidal archaeology, such as a submerged forest, and sampling peat deposits (Johns *et al*. 2009; Mulville and Johns 2010).

4.5 People in their environment

Wetlands, coastal marshes, and estuaries are resource-rich environments – highly valued areas with easily available freshwater and plentiful wildlife. In fact, estuaries and their fringing wetlands and low-lying hinterlands are some of the most biologically productive habitats on earth. That estuarine environments were abundant in Northsealand is evident from the seismic survey work outlined above. These ecologically important areas harbour immense numbers of microbes, plankton, and benthic flora and fauna due to rich nutrient supplies as well as organic matter of both terrestrial and marine origin. These are, in turn, a major food source for higher trophic levels, such as crustaceans, fish and shorebirds, which use the intertidal flats as nursery grounds for juvenile stages and as vital adult feeding grounds (McLusky 1989; Kennish 2002; Fujii 2006). This year-round resource abundance would have been of consequence to Mesolithic hunter fisher gatherers (Clarke 1978), and rather than seeing the wetlands of Northsealand as marginal space we should understand them as a major focus for activity.

As Northsealand's low-lying areas became inundated, extensive coastal shallows are likely to have been created. These would have been highly productive of edible molluscs and crustacea. They would have included brown shrimp and pink shrimp, while mussels are likely to have been present in abundance, as well as cockles, bivalves and deep burrowing organisms, such as the lugworm. Copious evidence for the exploitation of shellfish during the Mesolithic is provided by shell midden sites around the British Isles (Milner 2006 and references therein). Although these enigmatic sites are clearly more than just piles of food residue since they contain human remains and evidence for ritual activity (Conneller 2006; Chatterton 2006; Milner 2006; Chapter 6), they do demonstrate the collection of, say, limpets. Crab has also been recovered from Oronsay, and oyster is known from Ertebølle sites (Spikins 1999; Clarke 1978).

Northsealand's estuaries would have been important for fish species such as sole, plaice and cod, along with bottom feeders such as flounder, dab and whiting (Elliott and Hemingway 2002). Fish that use estuaries as a route from the sea to fresh water to breed, or vice versa, such as eel, stickleback, Atlantic salmon and sea trout, may also be present. Fish bones have been recovered from shell midden sites in Scotland, and include cod, whiting, haddock, pollack, and saithe (Spikins 1999; Rowley-Conwy and Zvelebil 1989), while mackerel was recovered from the late Mesolithic Danish site of Ordrup Naes (Rowley-Conwy and Zvelebil 1989). Eel has also been recovered in small quantities from a number of Mesolithic sites (Rowley-Conwy and Zvelebil 1989).

The remains of fish traps from the coasts of Denmark and other northwest European continental countries (Fischer 2004), as well as Dublin, Ireland (McQuade and O'Donnell 2007; 2009) provide further testament to the use of fish. Salmon would have potentially been an important resource since they can be caught in quantity during the salmon run (see Pickard and Bonsall 2004). Sturgeon is also likely to have been present in European waters.

Water birds attracted to these intertidal flats may have included brent geese, shelduck, pintail, oystercatcher, ringed plover, grey plover, bar-tailed and black-tailed godwits, curlew, redshank, knot, dunlin and sanderling. Greylag geese and whooper swan may have used this habitat for roosting (Davidson *et al*. 1991; Elliott *et al*. 1998). Coles (1998, 74) has previously pointed out the potential importance of Northsealand for migratory birds, and there is evidence for the exploitation of the whooper swan; a species only present now in winter in Denmark (Rowley-Conwy and Zvelebil 1989; Grigson 1989). Large numbers of Mesolithic period whooper swan bones have been recovered from Aggersund, Denmark, as well as the late Mesolithic site of Sølager, also in Denmark. Evidence from the latter site also included bones of eider and velvet scoter (Rowley-Conwy and Zvelebil 1989).

Evidence for the exploitation of mallard and wigeon come from the island of Téviec off the Breton coast, while bones of the flightless great auk have also been recovered from Scandinavian sites (Rowley-Conwy and Zvelebil 1989). Both seabirds and their eggs will have provided communities with an important resource.

Whale and dolphin or porpoise bones have also been recovered from Mesolithic contexts in Scotland (Smith 1992; Spikins 1999) and from Scandinavian sites (Bang-Andersen 2003), suggesting that they were also caught up in Mesolithic lifeways. Exploitation may have been opportunistic, taking advantage of beached or dead animals washed ashore. As Darwin remarks of the Tierra del Fuegans, when "the floating carcass of a putrid whale [is] discovered, it is a feast" (Darwin 1839, 178). The gently sloping shores of Northsealand may well have been conducive to the occasional whale beaching (Fitch 2011), while the Channel/Manche embayment may have seen whales travelling up it.

Mesolithic communities may also have hunted whales, as hunter fisher gatherer communities, such as the Inupiat in north Alaska (Sakakibara 2009), still do (although Pickard and Bonsall 2004 argue against this). As described in the next chapter, modern Inupiat communities in Alaska use whale skin for drum coverings and whales are a critical part of social life. Whales may similarly have been so in the Mesolithic.

Grey seal phalanges were recovered from hearth pits at Howick, Northumberland (Waddington 2007b) suggesting that they were hunted and eaten. Quantities of seal bones (both Common and Grey) have also been recovered from the Oronsay middens in Scotland (Mellars 1987) as well as in Scandinavia (Kvamme and Jochim 1989). Some sites in the Baltic regions are dominated by seal bones (Rowley-Conwy and Zvelebil 1989). Seals are therefore a species in which communities are likely to have engaged with routinely, probably knew intimately, and perhaps developed a close spiritual relationship with, as suggested by Nolan (1986) at Cnoc Coig. Seals would have been found in large colonies along Northsealand's coast (Fitch 2011) making multiple kills easy, although as Spikins (1999, 43) points out, they could also have been hunted at sea using bone harpoons.

Seals may have been important and sealing "an activity of vital interest to certain coast-dwelling communities in north-western Europe during the Stone Age" (Clark 1946, 12). As with whales and modern Inupiat communities, seals may have also been an important part of Mesolithic social life, with relations being socially mediated and maintained.

The littoral zones were clearly important areas, with sites such as Howick evidencing a marine-based economy for at least part of the year. Isotope measurements from human remains show differences between groups, with some heavily reliant on a marine diet, as apparent on Caldey Island in south-west Wales (Schulting and Richards 2002a) and groups occupying the Obanian sites in western Scotland (Schulting and Richards 2002b). Others appear to have been almost totally reliant on terrestrial meat, as indicated by, for example, the female skeletal remains recovered from a channel of the River Trent at Staythorpe and dating to around 5740–5630 cal BC (Davies *et al*. 2001; Passmore and Waddington 2012). It should be remembered though, that animals normally associated with terrestrial environments, such as Northsealand's woodlands and higher ridges, will, on occasions, have been attracted to the inundating intertidal zones. This is a fact attested by animal tracks and faunal remains dating to the Mesolithic period in the Severn estuary (Bell 2007). Certainly, where possible, in later periods coastal grazing on marshland was, and still is, a common way of fattening livestock.

Terrestrial animals in Northsealand will have included grazing and browsing fauna, such as deer, elk, aurochs, and pig, as well as bear and the smaller animals like hare, beaver, fox, dog, badger and hedgehog. These are all evidenced from Star Carr (Clark 1954), and some from the seabed itself. As with marine animals, they are likely to have been watched, tracked, stalked, hunted, processed, eaten, related to and symbolised. They will have been understood intimately and thus formed part of the rich economic and spiritual network of Mesolithic life.

Northsealand's wet marshland environment would also have provided reeds for basketry and other wickerwork, while flint and other stone will have been abundantly available, exposed in river valleys or the collapsed salt domes, or directly from the extensive chalk ridges. Further, wetlands offer safety and shelter, or have spiritual or religious importance, for example somewhere for the dead, as indicated by burials in Denmark, or a place for the deposition of objects (Chapter 6; Bradley 1990; 2000). Coastal wetlands are also important for transport and communication and the everyday movement of people via the navigable inland waterways and access to the sea.

There has been much discussion in the literature on coastal hunter fisher gatherers, particularly groups on the northwest coast of North America. Using such anthropological examples it has been argued that year-round resource abundance led to socially complex, and sedentary or semi-sedentary hunter fisher gatherer groups around the coast in the European Mesolithic (Price and Brown 1985; Spikins 1999 and Warren 2005 for a critique of the coastal complexity model). Recent work by Crombé *et al*. (2011) and Conneller *et al*. (2012) has, however, urged caution with regard to models that suggest a linear development of complexity from the early to late Mesolithic. It is worth pointing out that some features usually associated with a more sedentary lifestyle and greater complexity, such as the large buildings at Howick and East Barns, date to the early Mesolithic. A survey of the evidence from the west of Britain (Bell 2007) has also highlighted that some of the most densely occupied sites (such as Nab Head and Rhuddlan) began in the early Mesolithic.

The coastal zones, however, would certainly have been key areas. Without wishing to adopt a “marine deterministic” slant (Van de Noort 2011a, 14), the inhabitants of Northsealand are likely to have, to a greater or lesser extent, identified with the sea and water, and at times profoundly so. This may have been similar to the Aboriginal Saltwater People (Torres Straight Islanders) attested from the ethnographic record, who have deep spiritual connections with the sea, conducting rituals on it. For them, interaction within intertidal zones, including the use of fish traps, are more than just ways of procuring food, but part of broader ritual performances (McNiven 2003).

As Van de Noort (2011a, 94) has described, the style of mobility of coastal dwellers could have further identified them. They would have moved around on log boats, dead reckoning along coastlines and visiting islands perhaps to check fish traps. This way they could also have travelled up braided rivers to the woodland fringed wetlands further inland.

The coast (and wetlands in general) has its own patterns and rhythms of movement. Ebbs and flows that frequently mark it out as somewhere different. This provides the people, the land and the sea with a distinct identity (Harris 2013; Pollard 1996). Certainly, tidal rhythms influence “temporal patterns and rhythms of life” (Jones 2010, 189). Intertidal space, particularly the water’s edge, can be a rich transformative zone with distinct entanglements between humans, non-human organisms, and the sea. These entanglements also include perpetual and complex rhythms and pulses driven by, for example, the movements of the earth, moon and sun, the weather, seasonal migrations and social life (Jones 2010). The coastal zone is a dynamic landscape constantly being eroded or deposited on by the sea. It feels alive; rising and falling as if breathing and sighing. The land and the sea in this area belong together as one.

With shallow waters and flooded land, in certain parts of Northsealand’s advancing intertidal zone it may well have been, at times at least, difficult to tell where one ended and the other started. Interactions between people and the sea will have taken place across this margin, blurring any distinction between the two. It was neither just the domain of the land nor the domain of water, but both. This gives this landscape a particular ‘flavour’, which may have led to groups inhabiting Northsealand becoming distinctive ‘mari-terrestrial’ or ‘land-sea’ communities. This may also have made it easier for some to adapt to a fully sea-faring lifestyle following final submergence of their ancestral land (Chapter 6).

4.6 Chapter summary

This chapter has brought together some of the information from sites around and in the North Sea and Channel/Manche. Although far from comprehensive, it has provided evidence for the kind of land that was inundated in the North Sea lowlands. It has used very different types of information, from palaeolandscape studies to information from archaeological sites and geologically-based sea-level reconstructions. Not all, of course, entirely compatible. This has highlighted that the evidence from submerged sites is uneven and often poorly contextualised within broader narratives in prehistory. One of the main issues is the coarse, and frequently absent, chronological resolution to this evidence. It is also clear that much of the submerged landscape has undergone significant erosion and reworking of sediments and the original early Holocene landscape has been significantly affected.

This makes characterising the landscape difficult, whilst the lack of reliable pollen data makes determining the sequence and timing of vegetation development problematical. This is despite pollen analysis from sedimentary profiles going back to the work of Godwin (Chapter 1). Nevertheless, much is now changing and a new and exciting era of research on the submerged landscapes of Northsealand is beginning.

As Coles (1999) identified, Northsealand had three major river networks (Fig. 4.1). Two of these drained north, comprising the River Elbe, Wesser and Ems and associated tributaries on the northeastern side, and the River Ouse, Trent and Tweed amongst others on the northwestern. The south flowing river system comprised the Rivers Rhine, Meuse and Thames. One can postulate that these river networks also formed the major social networks in the early Holocene, perhaps with the Channel River to the south of the Dover gorge representing a fourth separate social area.

Topographically, Area 1 incorporates regions that were low-lying marshes, river valleys and lakes amongst low rolling hills. The major rivers in this area, such as the Trent and Ouse, Elbe and Ems, flowed north, draining into the North Sea embayment. The Outer Silver Pit, whether in its original incarnation as a vast lake or later as a marine outlet, with nearly 700 metres of lakeside/coastline, was a major topographic feature of Area 1, the importance of which should not be underestimated. It would have dominated the landscape and surrounded by salt marsh and fed by river systems through at least ten large estuaries must have attracted waterfowl and animals, and had fish and vegetational resources in abundance. As such it would have provided a major focus for people, with the river valleys acting as channels for their movement. Other major river systems, wetlands and freshwater lakes exist across Northsealand providing similar opportunities. Barton *et al*. (1995) have drawn attention to the use of rivers for travelling and as reference points, with watersheds as possible territorial markers.

Area 2 in the southern part of the North Sea was also a low-lying landscape. The major rivers in Britain and north-west Europe continued across this area and flowed south. This formed a major deltaic plain comprising extensive wetlands. Chalk hills extended across the southern part of this area, as did the Weald, and would have provided a major focus for activity. The south-flowing rivers converged and flowed through a gap in the Weald-Artois anticline (referred to as the Dover gorge after Hijma *et al*. 2012). This must have been an impressive and dramatic feature and perhaps highly attractive to people.

Area 3 represents the area south of the Dover gorge, which was dominated at the start of the Holocene by the wide and braided Channel River. This was fed by tributaries from southern Britain and northern

France. Chalk ridges stretched across this landscape and again a continuation of the activity evident from the terrestrial record is likely, perhaps with a focus along the banks of the braided Channel River.

The importance of this landscape has been stressed in this chapter, highlighting that these wetlands are likely to have been a focus for activity. Far from being an abstract landscape, we can now begin to see Northsealand as one that was real and inhabited.

Chapter 5

Changing worlds and changing worldviews

"Lord, the water done rushed all over,
down old Jackson Road
Boy, it starched my clothes
I'm goin' back to the hilly country,
won't be worried no more."
'High water everywhere', Charley Patton, 1929

5.1 Introduction

This chapter examines some of the possible effects of sea-level rise in Northsealand. It highlights how organisms and their environments are fundamentally connected through a complex network of interactions, from the biological to the physical, and from the smallest of organisms to the largest (Butzer 1982). Minor changes can lead to major consequences, many of which are subtle, complex and difficult to predict. However, throughout the focus is on the human perceptions and consequences of the changes brought about by sea-level change. This chapter emphasises, as set out in Chapter 2, that sea-level rise and the associated effects did not form a backdrop against which life occurred and were not something external to it, but was an indivisible part of life.

Coastal systems are dynamic, complex and exhibit non-linear behaviour, as small changes can have large implications. As set out in Chapter 2, environments are constantly changing, and we should not assume that Northsealand was 'stable' prior to sea-level rise. However, what will be highlighted below are the periods of rapid sea-level rise; the rise that would have occurred during and following, for example, the meltwater pulse events set out in Chapter 3. The changes that occurred during these periods were perceptible – not just across generations but within human lifetimes.

As will be shown below, relative sea-level rise has the potential to trigger a wide range of physical effects on ecosystems. Nicholls and Leatherman (1994) and Nicholls (2010) identify five main categories of landscape change due to sea-level rise. These are: submergence and loss of land, erosion of deposits, increased flooding and storm damage, saltwater intrusion into aquifers, and rising water tables. To these, this chapter will add: changing tidal regimes, changes to river dynamics and estuary morphology, reduced territory, the loss of flint sources, small island vulnerability and loss of place.

It should be noted that not all communities living in Northsealand would have been equally affected by sea-level rise. They would not have been uniformly exposed to the changes nor had the same resources to deal with them. Some communities, for example, would have been located further from regions affected by sea level rise (inland or beyond the 'hinge line'), while others would have been directly, and perhaps drastically, affected. The changes would have differed even in neighbouring areas, since coastlines vary greatly between localities; and so whilst a beach shoreline may be submerged by sea-level rise, a cliffed coast may be eroded and become dangerous. The local scale, as described in Chapter 3, is important. Further, differences between separate sectors of the community have the potential to highlight social disparities, perhaps serving to reveal previously hidden tensions between genders, classes, castes or age groups. There may also have been tensions between those communities affected by rapid sea-level rise and those beyond.

5.2 Submergence and loss of land

The submergence and loss of land is perhaps the most obvious consequence of sea-level rise. The speed of this process would have mainly been a function of the topography, with the smaller the slope gradient the greater the rate and extent of inundation (Fig. 5.1). This means that in a largely low-lying and flat landscape like Northsealand submergence is likely to have been, in general terms and with some obvious exceptions, a rapid process.

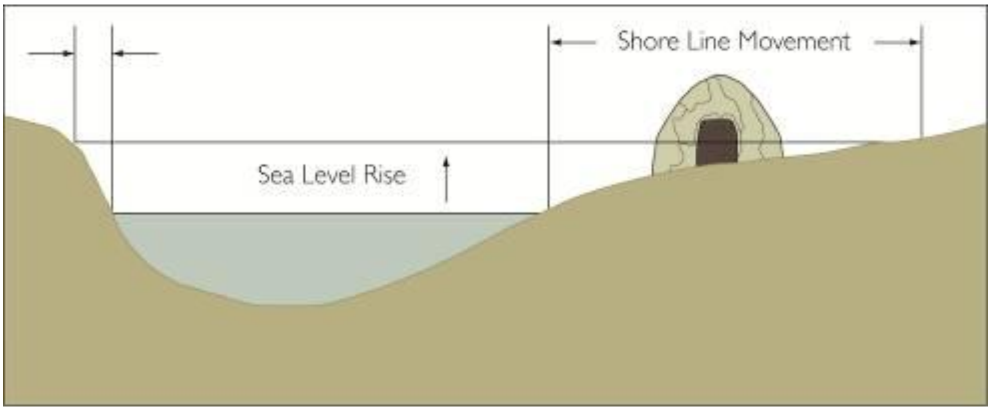


Fig. 5.1: Illustration showing how land loss is dependent on topography. (Redrawn and adapted from Leatherman 2001, 197).

Inundation would have resulted in higher water tables and boggy soils, as well as the invasion of halophytes (salt-tolerant plant species) (Leatherman 2001), and the development of salt marshes. These are evidenced across Northsealand in the extensive wetlands and salt marshes recorded around the Outer Silver Pit in Area 1 (Fig. 4.2), as well as in Area

2 in the Rhine/Meuse delta (Figs. 4.10 and 4.11 in Chapter 4), and the intertidal flat deposits off the Suffolk coast (Chapter 4).

Salt marshes can accrete vertically through biomass production as well as sediment deposition, and therefore keep pace with slow sea-level rise (Kearney and Stevenson 1991). However, where the rate of sea-level rise exceeds the threshold for this to occur, plants would have become waterlogged and the marshes not able to accrete fast enough (Leatherman 2001). This would have caused the ecosystem to collapse and the land to drown. Here we have a sense of the temporal scale involved, since such a process "can occur over wide areas within a few decades" (Leatherman 2001, 198). In other words, given the type of topography evidenced from much of Northsealand (Chapter 4), submergence would have been a perceptible process as thresholds were reached. This is certainly the case in the Rhine/Meuse river mouth in the middle to later seventh millennium cal BC where a rapid change from extensive wetlands to a coastal and estuarine environment is evident. This is possibly the result of a sudden sea-level rise caused by the '8.2 kya cold event' (Chapter 4; Hijma and Cohen 2011).

These low-lying ecosystems are important wildlife refuges, particularly for birds, as well as serving as important fish and shellfish nurseries, and would have been valued by Mesolithic communities (Chapter 4; Clarke 1978). Such habitat loss would have affected the distribution of a wide variety of taxonomic groups. In recent times, for example, landscape changes have caused barnacle geese off Norway to use more northerly sites on their migration route (Hickling 2006). For less mobile species, such as small mammals, small birds, reptiles and amphibians, insects, (the latter being particularly sensitive to changes and disruptions within the ecosystem), and many marine species, habitat loss would be more severe. Species respond individualistically to environmental changes through shifts in distributional range, and these shifts include emigration, local extinction, or immigration and colonisation by a new species – impacting upon the composition and structure of communities (Keith 2010).

As Keith (2010) shows, modern sea-level rise in the English Channel has significant consequences on the transport and population connectivity of marine organisms with a planktonic larval phase, significantly affecting patterns of distribution, and thus the surrounding food web. Removing 'keystone' species from an environment can have large implications for the biodiversity, stability and overall resilience of the ecosystem (Sievers 2012).

In Northsealand, submergence of parts of the landscape would have brought profound changes to the nature and distribution of birds, animals (including sea mammals) and vegetation. Some species would have increased in numbers whilst others decreased or disappeared altogether (*cf*. Spikins 1999; Macklin *et al*. 2000; Tipping 2004; Tipping and Tisdall 2004; Tipping *et al*. 2008 for vegetation changes throughout this period). The changing availability of vegetation would have led to a shift in the behaviour and migration routes of animals, such as deer, attracted by richer vegetation for forage and refuge, as well as their selection of calving grounds, whilst traditional migration routes may have become blocked and inaccessible due to submergence of land and changes to river systems.

There would also have been incidences of different species – new arrivals, as environments changed. These, no doubt, offered new resource opportunities, which would have been quickly exploited by humans. However, such changes would inevitably have put pressure on established subsistence activities and its overall productivity, possibly leading to changes in traditional hunting grounds.

Furthermore, as ground water tables in areas adjacent to the coast rose, ponding would have occurred, drowning the trees and producing what Fischer (1995) has termed ‘killing zones’ made up of swathes of dead woodland. The stumps of trees killed and submerged in this way have been widely recorded at coastal and intertidal sites around Britain (Hazell 2008). These areas include, for example, the Severn Estuary (Bell 2007) and Bouldnor Cliff (Momber *et al*. 2011), as well as further afield, in, for example, Denmark (Pedersen *et al*. 1997).

Consideration should be given to the significant loss that forest die-back would have imposed on local communities. From firewood and timber for building or renewing houses, trackways, boats, tools and other purposes, to the loss of plants — some perhaps important foodstuffs, others medicinal or totemic/sacred. Marine incursion would have affected soil microbes and fungi, which are strongly linked to plant survival and fecundity. Habitat loss would have led to the local extinction of organisms, reducing carrying capacity and thus species richness.

Additionally, there would have been the loss of woodland animals, such as wild pig, deer and elk, which would have moved on when the ground became waterlogged, and when there were no green woodland shoots to graze from or leaves to provide camouflage. Woodland birds too would have deserted the area, unable to feed on berries or hunt mice and other small prey. As woodlands died and land submerged, the whole environment would have been irreversibly altered, and with it fundamental perceptions, understandings and interpretations of place (discussed further below).

Submergence of the landscape would not only have modified its visual appearance, but its effects on other senses as well. For example, the acoustic profile of a place would have changed according to the varying proximity of a body of water. In this way the characteristic and familiar sound of a place may be different following inundation, challenging the very way a place is perceived and appreciated (Mills and Pannett [2009] for more on the Mesolithic auditory experience). The same is true of light, which also changes with proximity to water, indicated in the present-day by the large numbers of artists that congregate in, for example, St. Ives, Cornwall or Staithes, North Yorkshire.

It is also worth reflecting on how the recently submerged land, particularly the dead woodlands, may have been viewed. They may have been a harbinger of further flooding; an indication of sea encroachment. But they would have been eerily quiet, devoid of leaves, growth and much of the life that once dwelt amidst them. It is possible that mythologies grew up to explain this phenomenon – perhaps ‘killing zones’ became taboo areas or lands of the dead. Perhaps even the association with silence and death led to burials being located in submerging areas (Chapter 6). Canoeing through the Amazon floodplain, Harris recorded: “we fell silent as we entered the flooded forest. Indeed, it seemed to demand veneration. The trees were like pillars in a church so that it seemed we were moving through a watery nave" (Harris 2000, 56).

Fig. 5.2: Trees dying due to saline intrusion at Sowley Marsh near the Solent, Hampshire. (Photo Peter Murphy).

5.3 Erosion of deposits

Another process integral to sea-level rise is erosion of deposits, and in particular of sandy beaches. Settlements on the aeolian sand dunes in the Rhine and Meuse river areas, such as Hardinxveld-Giessendam in The Netherlands, which were occupied in the sixth and fifth millennia cal BC, or the persistently occupied sites on dunes in Sandy Flanders (Chapter 4) would have been particularly vulnerable to erosion. Higher sea-levels accelerate shore retreat by causing erosion further up the beach profile, with waves breaking closer to the shore, while long shore sediment transport is also increased due to deeper water (Leatherman 2001; Bruun 1962).

This process is explained by the Bruun erosion model (Fig. 5.3) which proposes that higher sea-levels cause sediment to be removed from the nearshore area and deposited in the lower part of the beach profile, allowing occasional high-energy waves (such as from storms) to attack further up the beach.

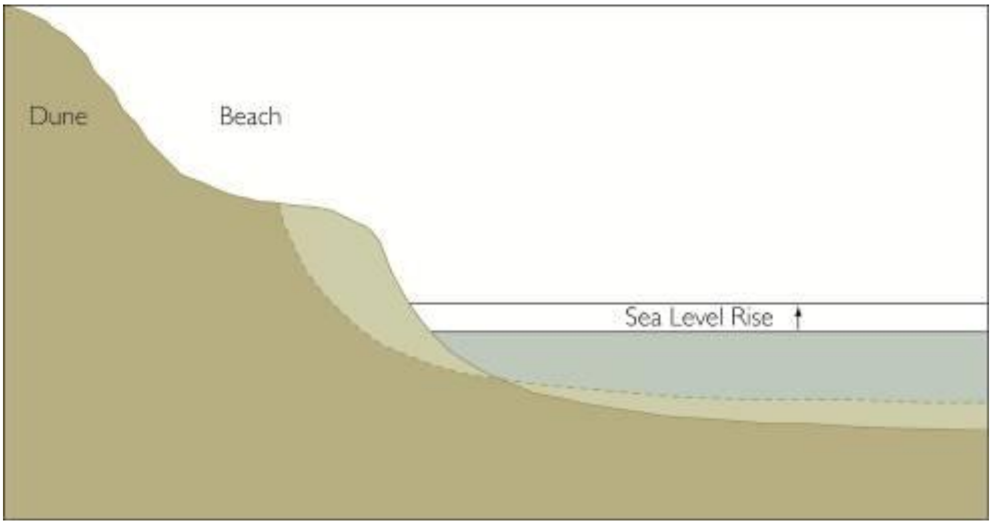


Fig. 5.3: Beach erosion based on Bruun’s model. (Redrawn and adapted from Leatherman 2001, 190).

Recent research on modern sea-level rise suggests that open-ocean sandy beaches erode at a rate that averages somewhere between 50 and 150 times the rate of sea-level rise (Leatherman 2001; Douglas 2001; Nicholls 2010). For example, a sea-level rise of 3.5 mm a year at the beach resort of Ocean City, Maryland, translates into five metres of beach erosion every decade, requiring a continuous programme of ‘beach nourishment’ to keep it in recreational use (Douglas 2001, 2). In this way, erosion will be considerably greater than the actual sea-level rise itself (Bruun 1962; Leatherman 2001).

Fig. 5.4: Beach nourishment on Hayling Island, Hampshire. (From James *et al*. 2011, 13).

While shores are highly dynamic, it is clear that sea-level rise would have increased erosion, particularly of sandy deposits, changing the shape and location of the shoreline and any occupied dune sites. Larsson (2007) has suggested that erosion of beach spurs and protective sand walls as a result of late Mesolithic sea-level rise in southern Scandinavia would have exposed previously protected and resource-rich lagoons. “In unprotected lagoons, the islands and shorelines lay open to the immediate onslaught of the sea, and thus the delicate balance between fresh, brackish and sea water was seriously affected” (Larsson 2007, 605).

5.4 Increased flooding and storm damage

Although flooding is a normal phenomenon in coastal zones, it increases as a result of sea-level rise, particularly in low-lying areas where it is a prelude to submergence (Few *et al*. 2004a). The loss of protective sand beaches, as described above, and the erosion of natural coastal systems such as wetlands, combined with submersion, removes natural defences and amplifies flood hazards. This increases the exposure of coastal human communities to extreme events such as storm surges and tidal waves (Nicholls *et al*. 2007). This would all have had an effect on Northsealand's coast, particularly when a critical threshold, such as a natural levee, was overtopped, rapidly inundating the land, and causing an irreversible process of drowning. Further, the breaching of coastal barriers, such as coastal headlands, as a result of floods and storms would allow propagules of intertidal species to move rapidly into new communities, changing ecosystems (Keith 2010).

As well as the immediate physical risks to people associated with severe flooding (such as, in some cases, direct physical injury, and, depending on the speed of flooding, possible drowning), other health risks include an increased likelihood of waterborne diseases. Human and animal waste and animal carcasses can be washed into water supplies, causing diarrhoeal disease (McMichael *et al*. 2006; Haines *et al*. 2006; Few *et al*. 2004a; Costello *et al*. 2009; Patz *et al*. 2005). Although perhaps a function of more settled communities, Few *et al*. (2004a) point to increased reports of cholera following flood events. Leptospirosis, transmitted from the urine of an infected animal, is also associated with enhanced flooding (Few *et al*. 2004a).

Further, some vector organisms (for example mosquito populations) can increase following floods due to the presence of stagnant, lentic or slow moving water, or through ponding as a result of rising water tables. Others (for example ticks) multiply with increased rainfall (Few *et al*. 2004a). Incidences of malaria are likely to have increased with the extension of waterlogged and marshy zones, and parts of Northsealand may have become ‘no go’ or ‘taboo’ areas as a result. Sallares (2006) points to the role of sea-level rise in the spread of malaria throughout the Holocene. Haines *et al*. suggest that “changes in climate that can affect the transmission of vector-borne infectious diseases include temperature, humidity, altered rainfall, soil moisture, and sea level rise” (2006, 2104).

There is a strong association between sea-level rise and an increased intensification of extreme events, such as storms and surges. This in turn leads to flash flooding and rapid loss of ecosystems (Lowe *et al*. 2010). More frequent wind storms would have led to heavier wave action, thus increasing the deterioration of the shoreline and associated ecosystem loss. Changes in the extent of sea-ice during deglaciation would also have affected wave behaviour, changing the fetch over which the wind was blown, and perhaps increasing wave action (Lowe *et al*. 2010).

Throughout the historic period, surges driven by mid-latitude storms have resulted in significant damage and loss of life in the area of the southern North Sea. This includes the devastating 1953 storm surge (McRobie *et al*. 2005), and the dramatic 1607 wave in the Bristol Channel and Severn Estuary (Fig. 5.5; Bryant and Haslett 2002; Haslett and Bryant 2004). Some models predict an increase in the height of future storm surges as a result of modern climate change (Lowe *et al*. 2010).

Fig. 5.5: Contemporary woodcut of the 1607 flood.

An increase in the frequency of extreme events, such as storm surges, would have had significant implications for intertidal macro benthos, and other organisms. Thibault and Brown (2008), for example, documented how after a catastrophic flood event in the southwest of the United States there was a wholesale reorganisation of a rodent community, with a complete change in the dominant species. This shows how a large perturbation can entirely and irreversibly change the outcome of ecological processes, and sometimes in the most unexpected of ways. In effect, it re-sets the ecosystem. Major storms can also clear tracts of woodlands (Brown 1997, 140–1), change ecosystems, and damage infrastructure, such as houses, platforms, fish traps and so on.

In the Mesolithic period, increases in storm events would have made conditions less predictable (see analogies with modern Arctic groups below). This is likely to have made travel and hunting more difficult, since it increases the chances of being caught out in a storm or getting lost.

Stronger winds and more violent wave motion on the coast may have resulted in dangerous boating conditions (*cf*. Tipping and Tisdall 2004), causing a drop in hunting and fishing opportunities. Rougher waters may also have led to fewer seals around Northsealand's coastline and perhaps changed fish and seal migrations. It will also have affected fish migration upstream, such as that of salmon (evidenced from Mesolithic sites, *cf*. Pickard and Bonsall 2004), upsetting the location and timing of harvesting.

5.5 Saltwater intrusion and rising water tables

As sea levels rose, saltwater would have intruded into coastal surface waters and freshwater aquifers and penetrated along rivers, contaminating them and making them unusable for drinking water. Its landward reach would have been further extended by storm surges or other high energy events, shortening the rivers and removing resources. Freshwater lakes within Northsealand were breached by the sea, and this would have had the effect of killing the fish and rendering the lake water undrinkable.

The most prominent landscape feature evident from Area 1 is the Outer Silver Pit (Chapter 4; Fig. 5.6). This was initially a very substantial lake (exceeding Lake Flixton in size) with nearby rivers (themselves likely to have been important routeways) draining into it. And as discussed in Chapter 4, the Outer Silver Pit may well have been a central node attracting aggregations of people, and perhaps with an abundance of sites surrounding it; Star Carr being an obvious analogue. However, by around 7550 cal BC it had become a tidal estuary (Fitch 2011; Fig. 5.6). Clearly, the impact of marine incursion on this feature would have been colossal, and a similar process would have occurred at other lakes, such as Sand Hole, Silver Pit, and Markham's Hole (Figs. 4.3 and 4.4 in Chapter 4).

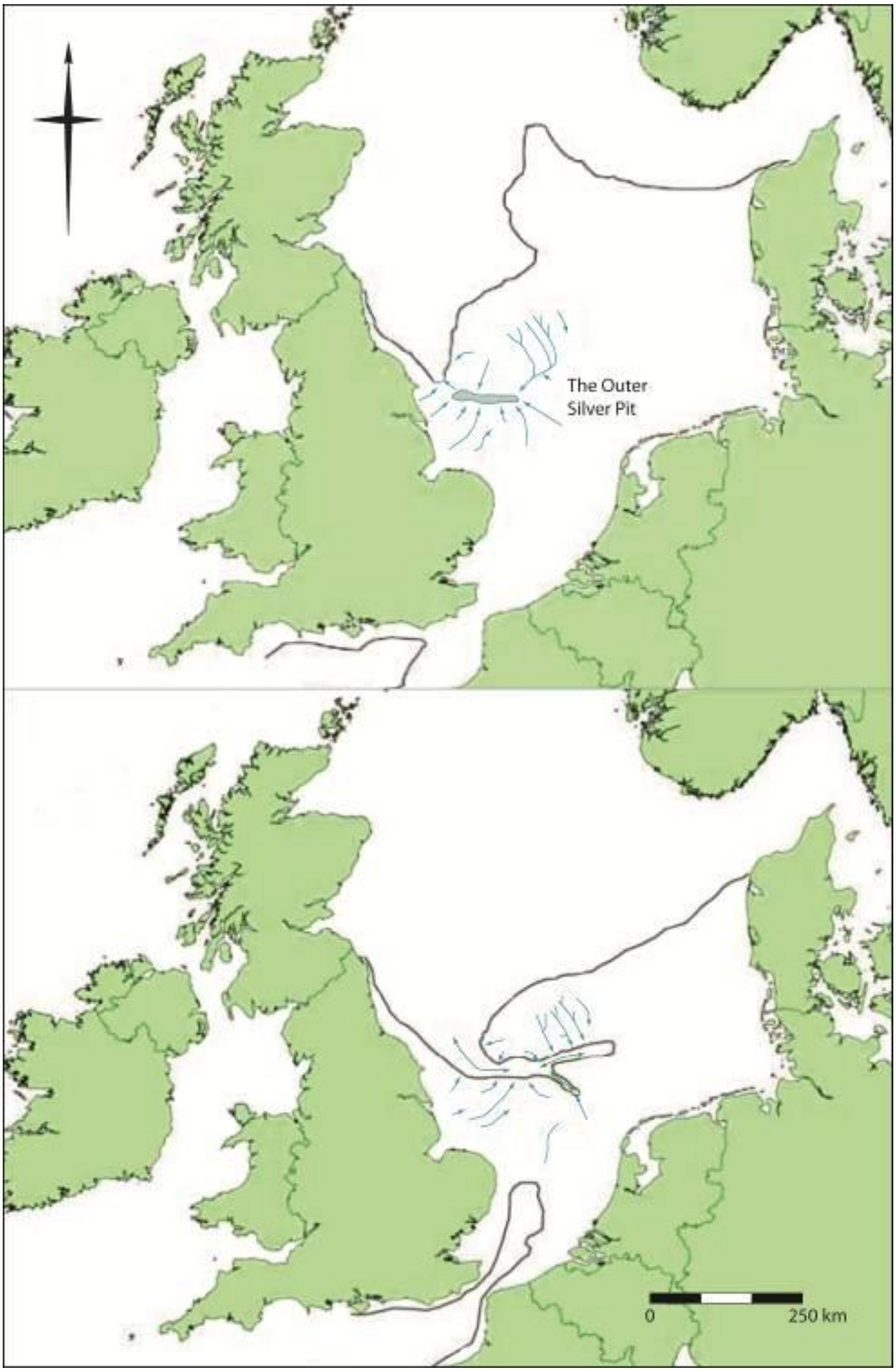


Fig. 5.6: The Outer Silver Pit 8050 cal BC forming a lake fed by rivers (top), by 7550 cal BC it had become a tidal inlet (bottom). (Adapted from Fitch 2011, 263).

Saltwater intrusion has the potential to have a profound impact on coastal communities, affecting individuals' health and making it a challenge to find sources of drinking water. As Henry Chu put it when discussing recent sea-level rise in Bhamia, Bangladesh:

> "global warming has a taste in this village. It is the taste of salt. Only a few years ago, water from the local pond was fresh and sweet on Samit Biswas's tongue. It quenched his family's thirst and cleansed their bodies. But drinking a cupful now leaves a briny flavour in the mouth. Tiny white crystals sprout on Biswas's skin after he baths and in his clothes after his wife washes them" (Los Angeles Times, 25 February, 2007).

Further, along the coastal zone the abundance, distribution and diversity of intertidal benthic macrofauna in estuaries would have been severely affected by salinity, impacting on higher trophic levels, such as fish, shorebirds and humans. It is likely that increased salinity would have caused a major decline of oyster beds in the later Mesolithic. Similarly it has been suggested that a decrease in salinity through the process of isostatic uplift can be detected by the virtual disappearance of oysters from Ertobølle middens in Scandinavia (Rowley-Conwy 1981; 1984). Such an ecological crisis, goes this particular argument, would have led directly to the adoption of farming. Although more recent work at other midden sites, such as Norsminde in Denmark, suggest a continuity of oyster exploitation into the Neolithic period (Milner and Laurie 2009). Any shift in salinity will severely affect the vegetation communities fringing the coastal areas through penetration of salt water into the fresh ground water table.

5.6 Changing tidal regimes

Although, as noted in Chapter 3, there would not have been a catastrophic breaching of the Dover Strait, the effect on the tidal regime when the North Sea and Channel/Manche embayment finally linked would have been very significant. This would have resulted in chaotic tides initially and a disruption of the food chain that may have significantly impacted on people living off marine sources in the area. Palaeotidal modelling (Austin 1991; Shennan *et al*. 2000) suggests that as the two seas met, there would have been a rapid increase in tidal range, which would have penetrated far inland through the river networks. Hijma and Cohen (2011) identify possible evidence for the consequences of this in the Rhine/Meuse floodbasin, where it is thought to have caused the rapid abandonment of some channels, such as the Meuse. Long *et al*. (1996) have also identified sediments on the southeast coast of England indicative of chaotic tides, which they suggest might be associated with this breach.

Certainly, the disruption to the food chain would have been considerable, affecting plankton, fish and shellfish populations and other marine organisms (Field 2008). This, in turn, would have influenced and changed people's diets. Further, the consequences would have rippled deep inland through extended tidal ranges along rivers.

5.7 Changes to river dynamics and estuary morphology

Seismic surveys have revealed a plethora of fluvial systems with clear dendritic tributary channels and associated tributaries in the southern North Sea area. This includes the over 600 metre-wide Shotton River channel (see

Fig. 4.2a in Chapter 4 for location), which would have been a substantial and prominent feature in the landscape in Area 1 (Chapter 4). As well as the Rhine/Meuse-Thames delta in Area 2 and the Channel River and associated tributaries in Area 3. As set out in Chapter 4, Northsealand could be described as a largely fluvial landscape.

In Area 1, these river systems predominantly drained into the Outer Silver Pit. Discussing the seismic work in this area, Fitch (2011, 223), points out that “the marine inundation would have shutdown almost all of the fluvial systems”. By timeslicing seismic data on the north side of the Outer Silver Pit, Fitch (2011) has shown that a deeply cut meandering river channel is overlain by a coastal embayment (see Fig. 4.2c in Chapter 4), indicating abandonment and burial of the channel with later intertidal deposits as sea levels rose. This is a process that would have occurred across the landscape throughout the Mesolithic period. Not only would the loss of rivers have had an impact on human territory size (see below), but also on the availability of fresh water.

In the shorter term, rising sea level would also have resulted in morphological changes to the coast, particularly estuaries, due to increased water depth and enhanced wave and tidal energy. These include coastal steepening and the removal of finer sediments leading to higher tidal levels. Also included are the redistribution or migration upstream of landforms such as subtidal bedforms, intertidal flats, saltmarshes, shingle banks, sand dunes, cliffs and low-lying hinterland (Goss-Custard *et al*. 1990). Further, increased sedimentation as a result of lower river flow velocities would have had important consequences for the courses of rivers, changing and bifurcating them and raising river bed levels. In turn this would have led to further changes upstream, extending the landward impact of sea-level rise.

While an estuary may re-establish its original structure further upstream, changes to salinity, tidal energy, sediment size and intensified siltation rates would have an immediate impact on the organisms within the areas affected, resulting in significant biological loss. As Fujii (2006) has shown in the Humber estuary, the species richness, abundance and biomass of present-day invertebrate assemblages are strongly affected by physical changes to the ecosystem, and this in turn affects the estuarine food webs. Archaeological evidence for this has been suggested at the Mesolithic and Neolithic shell midden at Norsminde in Denmark where increased sedimentation is suggested as a cause for the decrease in size of oysters (Milner and Laurie 2009).

Changes to freshwater inflows into estuaries further alter the system, resulting in significant effects on, for example, phytoplankton populations and fish nurseries. An increase in water temperature could affect algal production and therefore the availability of light, oxygen and carbon for other species (Nicholls *et al*. 2007). This would have significantly impacted on the abundance and biomass of all organisms, from the microscopic level to the consumers they support, such as fish, shrimps, shorebirds and people. Further, changes to the environment influence numerous aspects of fish physiology and ecology, for example behavioural responses of fish have been shown to include migration and changed activity patterns (Sievers 2012).

5.8 Reduced territory

The reduction of the length of river valleys as estuaries were pushed inland, as well as the loss of land in the coastal regions due to the processes described above would have had a major effect on human territory size and must have required a reconfiguration of mobility patterns. In the Severn Estuary the average reduction in river length in the millennia following the last glaciation has been estimated as 46% (Bell 2007, 335). In Northsealand, entire fluvial systems such as the Channel River, Shotton River and others around the Outer Silver Pit were lost through this process. This is likely to have affected a substantial proportion of the inhabitants since activity may have focused along river valleys (Field 2008).

Although a population increase throughout the later Mesolithic has been suggested (Jacobi 1976b; 1978a; Myers 1986; Smith 1992), and some have suggested reduced territories (Mellars 1976; Jacobi 1979; Donahue and Lovis 2006), the picture is far from clear (Spikins 1999; Chatterton 2005). However, loss of land as a result of sea-level rise is likely to have caused a 'coastal squeeze' with some people forced ever further inland (see Chapter 6), possibly along river systems, placing greater pressure on the landscape.

Waddington has suggested that long-lived Mesolithic buildings such as Howick, East Barns and Mount Sandel may indicate a greater territoriality (Waddington 2007b, 197). A result of this may have been increased tensions and warfare. Likewise, it has been argued that the Chumash maritime hunter fisher gatherers in California increased warfare during the Medieval Climatic Anomaly as a result of resource shortages (Johnson 2000). A similar circumstance has been suggested in Friesland, The Netherlands, in later prehistory; although Fokkens (1998) points out that population pressure could have been offset by migration of people and an intensification and diversification of resource exploitation (Chapter 6). In the Mesolithic, such pressures may have increased tensions and led to greater violence between communities. This has been suggested by the evidence from human remains at, for example, Skateholm (Larsson 1988a; Mithen 2003) and beyond (Price 1985; Schulting 1998; Thorpe 2003).

Reduced territory, crowding and increased social engagement may also have led to social intensification (Evans 2003). And it should be remembered that social tensions can lead to the development of sub-cultures (grouped by, for example, religion, ethnicity or sexuality), which can flourish and enrich social lives more broadly. The point here is that not all effects were entirely and necessarily negative.

5.9 Loss of flint source

Another important aspect of the inundation and submergence of Northsealand would have been the cutting off and loss of important flint sources; a point first made by Pitts and Jacobi (1979, 174). In the Vale of Pickering in North Yorkshire, for example, the Long Blade sites of the Pleistocene/Holocene transition employed good quality glacial till material presumed to have been collected from a source somewhere in the now drowned North Sea plain. However, by the early Mesolithic, beach pebble was used for tool manufacture, most probably as a result of the inundation of the original flint source (Conneller *et al*. 2012; Conneller and Schadla-Hall 2003).

A similar situation can be argued for the southwest peninsula of Britain where there is a change from larger, high grade translucent flint in the earlier Mesolithic to the use of smaller beach pebbles in the later (Pitts and Jacobi 1979). Further shifts in raw material use come from the exploitation of Blackdown chert in Somerset, which appears to be only locally used in the early Mesolithic but more widespread later on, perhaps as other sources became cut-off (Pitts and Jacobi 1979). In this context, it is interesting to note the shift in use from Wommersom quartz in the early Mesolithic to Tienen quartz in the middle Mesolithic in Sandy Flanders (Crombé *et al*. 2011, 468). This is a situation that may well be true for many of the North Sea coastal sites, and more work is required to analyse the chemical signatures of tools used on coastal Mesolithic sites to identify possible source materials.

Flint sources have been linked to particular tool types (for example, Chatterton 2005), and people evidently travelled to specific locales to select stone appropriate for use. Therefore removing a flint source, which would have been valued for its physical, symbolic and other properties, may have significantly disrupted the process of tool manufacture, obligations, social duties, ontologies and lifeways. The higher chalk areas, for example along the Yorkshire coast (Area 1), or the chalk upland around the Dover gorge (Area 2), or in the eastern Channel/Manche (Area 3), like their now-terrestrial counter-parts, would have been flint-bearing and potentially of great importance in the early Holocene. High quality flint from the chalk between the later flint mines of Cissbury in Sussex and Jablines and Spiennes on the Continent may have been particularly valued. It was noted in Chapter 4 that the Cross Sands Anomaly (Fig. 4.6 in Chapter 4 and Fig. 5.7) in Area 1 is likely to be flint-bearing. If, as suggested, it had a sacred status, any flint collected from it may also have been regarded as special.

Tolan-Smith (2003; 2008) has suggested that establishing the source of raw materials can take time when a group moves into unfamiliar territory. In the context of displacement from Northsealand and the removal of earlier flint sources, therefore, the use of flint material in the early Mesolithic at Deepcar, near Sheffield, which originated from 80 km away, is interesting (Tolan-Smith 2003; 2008).

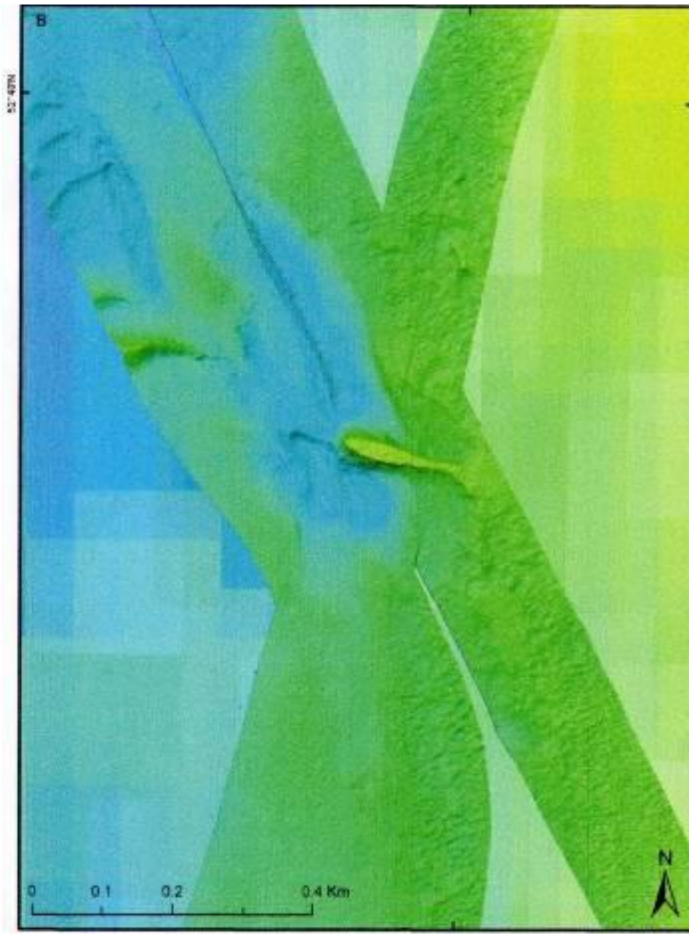


Fig. 5.7: Multibeam bathymetry of the Cross Sands Anomaly. (From the East Coast REC, Limpenny *et al*. 2011, 90).

5.10 Small island vulnerability

Small offshore islands that formed as the low-lying areas flooded leaving higher areas standing proud of the water, would have been particularly vulnerable to even small rises in sea-level. Small islands could have included the Cross Sands Anomaly (above and Chapter 4), and areas of higher chalk identified in Areas 2 and 3 (Chapter 4). While small islands would have varied, all the above described effects: land submergence, beach erosion, increased storm flooding, higher water tables, salinity intrusion and overall reduced fresh water supply, would have been profoundly felt.

Eventually these islands were lost altogether and (where occupied) would have resulted in off-island migration (see Chapter 6). These islands would also have been particularly susceptible to natural hazards, such as the Storegga slide tsunami. This is due to their small size, limited range of natural resources, little biological diversity, relative isolation, and extensive land-sea interface exposing them to greater erosion and submergence. Greater vulnerability, as well as an insularity and remoteness of human groups on such islands, may have provided a feeling of being marginalized.

5.11 The loss of place

As set out in Chapter 2, when landscapes changed and disappeared it was not simply a backdrop that went – something that could be re-created elsewhere. It was a landscape that was alive, that had a past, both mythical and historical, and was inscribed with paths and places that were meaningful to the people who lived within them. Because of temporal depth, the landscape was something that provided identity to a society or individual and *vice versa*.

The discussion in Chapter 2 served to show the fundamental links between people and their surrounding environments and the rich and essential nature of place. The Mesolithic landscape was imbued with meaning, and Northsealand would have been no different. The sites in the Flevoland polders or Sandy Flanders, or the scatters of flint dredged up from the depths of the North Sea by trawlers, indicate places – locations where lives were acted out by people who would have had an intimate knowledge of that area. They were places that invoked memories, and people would have been attached to them. They would have had special significance to family histories, to kinship ties, and held meaningful, emotional memories to descendants.

Many of the natural features too, such as the Cross Sands Anomaly, the Outer Silver Pit or the Dover gorge, were potentially wrapped up in myths and stories. Equally, they may have been considered animate and fundamental to the myths and origins of people; perhaps thought to be places where the spirits dwelt. Or even the physical manifestation of powerful deities. They would have had stories and memories attached to them and been the focus of songs. These would have been places where an individual's parents were killed, or where they were initiated or where some other significant social event had once occurred. Others would have been traditional hunting grounds connected by a network of paths and travel routes. As set out previously, such places would have provided a narrative and a sense of identity to communities, and may well have been bound up with cosmogonies.

Fig. 5.8: Photograph of a Mesolithic footprint at Goldcliff. (From Bell 2007).

Footprint tracks recorded at Goldcliff in the Severn Estuary, which date from around 6300 cal BC to 5500 cal BC, make the archaeological record tangible. But they also cause us to remember that these paths were lost and truncated during contemporary use, (*eg* rapid sedimentation was attested at Goldcliff with up to 19 mm per year [Bell 2007, 222]). This would have impacted on an individuals' travel routes, and may have either removed or blocked access to traditional hunting grounds.

If, as Ingold contends, by "journeying forward along a path or trail, one is also taken back to places imbued with the presence of ancestors" (Ingold 2000, 148), and "to perceive the landscape is … to carry out an act of remembrance" (Ingold 2000, 189); how would a drastically changing landscape affect this? Ingold illustrates this act of remembrance with a particular example worth citing here. The example comes from a study of the Koyukon of Alaska by Richard Nelson (1983), who was

> "taken by an old woman to see a place in the forest where, long ago, the late Chief Henry and his wife Bessie had their fishing camp. Looking closely, one could make out dark bands on the birch trees, where the bark had been removed from which Bessie used to make baskets, and axe marks on the rotting stumps of trees that Chief Henry had felled. Examining these signs … Nelson's companion began to talk a little sadly about the deceased couple and their activities … [They] enabled [her] to recognise the signs of the couple's erstwhile presence in an otherwise featureless and overgrown patch of forest" (Ingold 2000, 148).

So, what, then, if that patch of forest had disappeared and the rotting stumps, with their axe marks, were hidden from view under water? The old woman would no doubt still remember Chief Henry and Bessie, and may even be able to point to the now inaccessible land where the camp once was; however, without being able to move through this landscape, some memories are not regenerated and an important cue in the landscape would be lost. The loss of traditional paths may have had considerable social implications (Leary 2009).

The point here is that we have to think beyond inhabitants simply mapping their old places on to a new area, re-creating it elsewhere as land submerged. Place is far more complex than this (Chapter 2). That is not to say that they could not re-create their cultural layout somewhere else, but rather that they could not merely transfer their embodied place, their memory place, their childhood place, their place that gave them and their community an identity (Chapter 2). That, along with the narratives that kept those places alive, was lost during the process of the submergence of Northsealand.

As set out in Chapter 2, human-environment relations are integrally linked, and modern Arctic groups may here provide a useful analogy to explore these relationships and provide further ways of understanding the consequences of the changing environment for Mesolithic communities. In Sachs Harbour in Canada, for example, reports suggest that more frequent and intense storm events as a result of modern climate change are making boating conditions dangerous, as well as affecting the distribution of sea mammals (Jolly *et al*. 2002). Unpredictable storms can make travel and hunting difficult, and in Baker Lake in Nunavut Canada navigation has been affected, since winds are used for navigating the tundra. The prevailing northeast wind causes grass to bend and freeze in a southwest direction, allowing travellers to set their bearings (Fox 2002). But unpredictable wind patterns mean that they now have to be careful using these for orientation. There is here a loss of trust in the weather and the landscape (Fox 2002). Further, traditional hunting grounds are becoming inaccessible due to changes in the landscape, and some traditional campsites have been washed away by river surges caused by meltwater (Fox 2002). Again, this is not just a practical problem, but constitutes an altered physical and soul engagement with the inhabited world.

Inupiat communities around Barrow in north Alaska have similar problems regarding whaling (Sakakibara 2009). The Bowhead whale is central to their culture and each year there is an elaborate series of musical rituals involving singing, dancing and drumming, using drums made from whale skin. Through their skins the whales provide the music, enabling the mediation of human-whale relationships and closer ties to be constructed (Sakakibara 2009). However, inconsistent wind directions have made whaling difficult, with obvious economic implications to communities. But more than this: some believe that without a whale harvest there should not be any performances – as one community member put it ‘no whale, no music’ (Sakakibara 2009). This is partly the practical problem of a shortage of drum skins, but at a deeper level it shows that their relationship with whales has been fundamentally changed.

To take different ethnographic examples, in the 1950s the construction of the Kariba dam and subsequent widespread flooding of the Zambezi River in Africa resulted in the forced large-scale displacement of Gwembe Tonga tribes people from Zambia and Zimbabwe. Amongst the consequences of this was the loss of traditional shrines, which were not rebuilt due to the potential spiritual dangers emanating from the resettled area, including the existence of lingering ancestors. This had “a profound impact on ritual activity”, which was suspended for four years (Torry 1978, 172). Other recorded consequences included the movement away from kinsfolk leading to a weakening of social ties, anxieties about new neighbours, and faith in many of the chiefs being eroded (Torry 1978, 171).

Similarly, resettlement of people from alongside the Volta river as a result of the Akosombo dam resulted in people sharing space with others “whose languages and customs they did not understand” (Torry 1978, 175) leading to anxiety. Many of the gods of the Ewe and Akan people affected by the resettlement were linked to particular places in the drowned landscape. It was believed that some gods could be persuaded to move, but others were so securely linked to places that they refused to leave and were inundated (Yarrow 2011 and pers. comm.).

More recently, between 2005 and 2010 villages in El Gourna, Egypt, were relocated from alongside the River Nile to a new site a few kilometres away in order to protect the historic environment (Duggan 2012). This led to significant social fragmentation, but one of the main consequences residents spoke of when interviewed was the sense of loss and sadness experienced when leaving the old village. As one resident put it: "painful, painful. My father and my mother they cried … that was too sad. In old Gourna, it was my life and it was my memories" (Duggan 2012, 20).

These examples serve to show that changes to the landscape have major impacts on the environment and everything in it, including people. The effects are complex, involving a range of close interactions and cause-and-effect relationships, and the results are not always easy to predict as an outsider. People have a personal and intimate relationship with their surroundings, and when that environment becomes unfamiliar and its behaviour unpredictable and unexpected it creates a strong emotional response. The hunters in Nunavut, Canada, for example, who have had to change their hunting strategies and the locations of their campsites due to modern climate change, 'miss' the areas in which they use to hunt.

> "In some cases, these places have special significance to family heritage or hold meaningful memories for individuals. Many hunters and elders are extremely attached to the places they come from and travel to. They are tied to the land through their intimate knowledge of its paths and processes, but also through emotions and a sense of identity" (Fox 2002, 44).

This highlights the other side to landscape change rarely discussed in the archaeological literature: such consequences do not come without considerable personal stress. That is to say, people are troubled by their land changing, and the changes to their lifestyle this entails, and it causes a degree of ontological stress (Leary 2011). Hence, changes to the environment do not simply affect subsistence practices, but the individual and community's health and wellbeing, and people relate to the changing environment emotionally. Mental health problems such as anxiety, depression, stress, or even, in the case of sudden events, post-traumatic stress disorder, are acknowledged issues following flooding (Few *et al*. 2004a).

It is also interesting to reflect on how those that moved from flooded regions (discussed in Chapter 6) were seen by others. As with modern traveller groups or refugees, being 'placeless' can also be a source of anxiety and a focus of suspicion from others, and it may have been so in the Mesolithic period. People without a place are frequently marginalised, homogenized, and racialized. Ethnic groups are often conflated into a single group identified by their very displacement, their placelessness. They become people 'out of place' (Cresswell 1996); they are 'foreigners'. It is difficult to know how much of this is a product of a modern, sedentary view of the world; nonetheless, placeless people are likely to have been, at least at first, considered different – as 'other'. They would have had traces of elsewhere about them. This would have been particularly marked where one linguistic group moved into the region of another.

5.12 Chapter summary

Perception is clearly a key factor for how people respond and adapt to changes (Grothman and Patt 2005; see Chapter 6). As described in Chapter 2, perception is a complex sensory process, and develops gradually through a person's social and cultural background, education, experience, observation, understanding and knowledge over a lifetime. While sea-level rise is a long-term process, and erosion of beaches may have a lag-time, Nicholls describes, submergence, flooding and saltwater intrusion as having an "immediate effect" (2010, 22). In other words, many of the effects would have occurred at a human scale, within an individual's lifetime; they would have been seen and felt. Indeed submerged tree stumps provide powerful and evocative evidence for the rapid submergence of land. Describing the loss of land during the Mesolithic simply as an 'inundation' misses the human impact.

Effects of sea-level rise would have included the loss of salt marsh – an environment rich in resources, while coastal embayments and tidal inlets are likely to have infilled due to changes in the coastal regime. Estuaries would have come under the influence of an advancing saltwater front driven by coastal submergence. This would have increased salinity followed by submergence, displacing or removing the existing coastal plant and animal communities. Changes in sediment regime would have also led to a reduction of the habitat quality.

In addition to a straightforward loss of intertidal area, the remaining area was likely to have become steeper and composed of coarser sediment particles, particularly around the outer region of estuaries. It has been suggested that the effects included the loss of intertidal habitats that support a diverse ecosystem, as well as salinity intrusion and beach steepening. Flood hazards could have caused injury or death, as well as a range of diseases and other outcomes, including diarrhoea and malnutrition.

Furthermore, as sea-levels rose, places were lost and people moved. Relocation as a result of large development projects is, in modern times, the principle reason for human displacement, and there are few instances where resettlement has been able “to improve, or even restore, the livelihoods of a majority of those who must relocate” (Scudder and Habbob 2008, np). While we obviously have to be careful in drawing comparisons from modern people, particularly agricultural groups, it is an understandable point that people are affected not just by losing land, but by losing their place and the personal meanings it involves.

The different effects of sea-level rise would have been perceived at different levels and rates. In her study of the impact of sea-level rise on farmers in Maheshkhali on the south-eastern coast of Bangladesh, for example, Akter (2010) notes that overflow by high tides and storm surges, as well as salinity contamination of the soil and ground water, are the most easily observed effects of sea-level rise, with most respondents in her study having witnessed them. Over half also noticed a decline in animal populations, probably largely the result of more frequent natural disasters. Similarly, in a study of farmers in the Limpopo River Basin, South Africa, Gbetibouo (2009) found that about 95% of the interviewed farmers perceived long-term changes in temperature and 97% perceived changes in rainfall over the last twenty years. The point here is to suggest that many of the changes that occurred in Northsealand were likely to be perceptible, and occasionally catastrophic.

This chapter has discussed some of the likely effects of sea-level rise. While these changes are physical in nature, they have been approached by constituting the human and non-human world under a single relational rubric. In this way, it has been shown that people are not detached entities existing separately from the landscape and with change as a backdrop, but as an integral part of the world.

Not all communities living in the North Sea basin were equally affected by flooding, and clearly different settlements and taskscapes would be differentially susceptible, with the most affected and particularly vulnerable areas being coastal dunes, coastal wetlands, estuaries, and small islands (Leatherman 2001). The effects of sea-level rise cannot be easily summed up or characterised; it was highly variable, playing out in different areas in different ways and over a variety of timescales. Further, differences between people, behaviour, topography, technology, and access to resources such as water, would have led to different adaptations and coping strategies. Local-scale differences must be stressed, such as differences in gender, age, and disabilities (see discussion of the local-scale in Chapter 3).

Mesolithic inhabitants of Northsealand must have had, at times, the sense of the ground shifting beneath their feet as the sea advanced and habitat disappeared. There would have been disorientation as the landscape was reshaped, becoming alien to the very people who had previously prided themselves upon an intimate knowledge of it – the arcane knowledge of place rendered obsolete. Familiar geographies would have been disrupted and transformed, providing people with a sense of dislocation. When natural levees were overtopped and thresholds crossed, place was made strange and became defamiliarised. As links with places were severed there must have been a form of disconnection.

Places develop through an active engagement with the physical world (Chapter 2). Through the knowledge, the familiarity, the experience of it; the smell, the sound, the sight, the feeling, the pattern of the weather, the nature of the geology, flora and fauna. It is through all these factors that an understanding of place is formed, and by moving through this sensuous, embodied landscape, memories emanate and the world is opened up (Chapter 2). Mesolithic inhabitants did not construct their world inside their heads, but engaged with it and dwelt in it. The loss of this landscape in the Mesolithic period – the loss of these places, these familiar locales where myths were created and identities formed – could have profoundly affected people's very sense of being.

Chapter 6

Living in a changing world

"Life is neither static nor unchanging. With no individuality, there can be no change, no adaptation and, in an inherently changing world, any species unable to adapt is also doomed." Jean M. Auel, 1985.

6.1 Introduction

Adaptability or adaptive capacity is the ability to learn and adjust to changes in the environment, to moderate and mitigate possible damage, to take advantage of opportunities, and to cope with the consequences. It is, in other words, the process of learning and adjusting practices, and the environment, to manage and take advantage of the local conditions (Ford & Smit 2004; Ford *et al*. 2006; IPCC 2007; Pearce *et al*. 2010). Here we should see it "as an active process of becoming, rather than an achieved and static state of being" (Mithen 1990, 8). In particular, it is a process of becoming in relation to the environment (Chapter 2; Ingold 2000). Adaptation therefore is not a 'thing', but part of getting on with life. This is similar to Bourdieu's *habitus*: a set of principles, shaped by past circumstances and ways of doing things, enabling people to deal with unforeseen and ever-changing situations (1977, 72).

Although responses to change are difficult to categorize, different threads are apparent. Discussed in this chapter will be the role of practice and belief, mobility and migration, knowledge and information (particularly how accumulated knowledge of the environment can increase resilience), social networks and exchange, flexibility, intensification, diversification, and technical adjustments. Finally, opportunities that can come out of environmental change, such as experimentation, innovation and creativity will be briefly discussed. In practice, responses are likely to have been entangled and hybrid, combining many of these elements (which are, after all, fundamentally interrelated), rather than any single one.

6.2 Practice and belief

One response to sea-level rise, and perhaps a process that occurred over a longer time period, may have been to intensify ceremonial and ritual practice along the shoreline. Both Pollard (1996) and Bradley (2000) have highlighted the importance in some circumstances of the shoreline as a liminal and transitional zone from one spiritual domain to another (a point further discussed by Menotti [2012, 188–202]; and Brown [2003]). It may be that an advancing shoreline was of particular focus during periods of perceptible sea-level rise.

Such a focus may be evident at a number of sites in The Netherlands, including at Hoge Vaart-A27, where clusters of worked flint were buried, along with aurochs skulls, in wet and inundating locations (Fig. 6.1; Peeters 2007, 201–2). Further, the construction of the Europoort harbour near Rotterdam led to the discovery of over five hundred bone and antler barbed points dating to the late Mesolithic period. Verhart (2004) interpreted these functionally, as lost hunting gear. Similarly, flint 'dumps' of axe knapping waste were recovered "in a saturated part" near the shoreline at the Mesolithic settlement site of Vaenget Nord at Vedbaek, Denmark (Petersen 1989, 328).

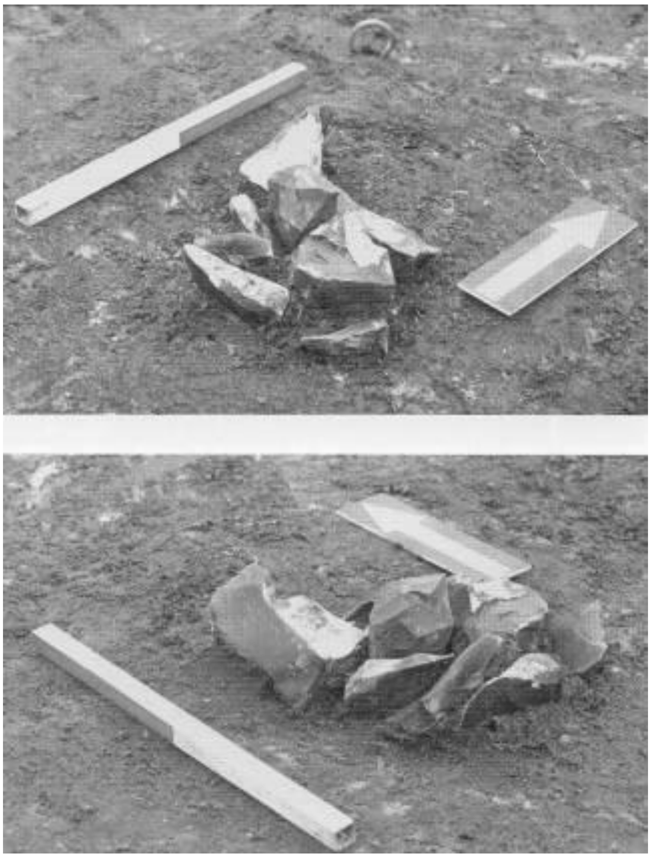


Fig. 6.1: The formal deposition of flint cores and flakes in a peat layer from Hoge Vaart-A27. (From Peeters 2007, 201).

Flints deposited in pits may represent caches, perhaps in response to the loss of flint sources in Northsealand (Chapter 5). However, there is a different way of seeing these artefacts and assemblages, and the inundating zone may have been deliberately selected for their formal deposition. A similar process has been suggested by Bergsvik (2009) to explain a marked concentration of middle and later Mesolithic adzes and mace-heads along the shoreline in Norway. Likewise, this has, although very tentatively, been suggested for artefacts along the eroded Mesolithic shoreline beyond the settlement at Goldcliff in the Severn estuary (Bell 2007, 225). Artefact deposition may have occurred in land/sea transitional zones as it is precisely these areas that vegetation is sparse as a result of saltwater die-back and therefore the visibility of artefacts, however temporary, was most pronounced (Evans 2003).

Later Mesolithic coastal middens around the North Sea basin also frequently evidence formal deposition, such as axes, *eg* Culverwell, Portland on the south coast of England (Palmer 1999), or human remains, *eg* Oronsay, Scotland, and Ferriter's Cove, County Kerry and Rockmarshall, County Louth in Ireland (Conneller 2006; Chatterton 2006). These coastal middens perhaps "referencing some kind of textural boundary … between land and sea" (Evans 2003, 61).

One could envisage this as a way of placating the waters or water spirits that were transgressing onto land. Bonsall *et al*. (2002a) have in the same way suggested that figural sculptures at the Lepenski Vir site in the Iron Gates, Danube valley represent mythical ancestors ('fish-gods'), intended to protect the settlements against the threat from flooding.

In this context, one can speculate as to the presence of a type of sea-level rise shamanism, similar to the Chumash Indian 'weather shaman' of south-central California (Johnson 2000). Strassburg has provided an evocative account of how wetland deposition may represent "desperate shamanic attempts at maintaining social control and status" in the face of sea-level rise in the Scandinavian Kongemose (Strassburg 2000, 115). Similarly, Sheets (2012) points out that sudden change, particularly a catastrophic event, has the potential to undermine confidence in religion, and may even facilitate the emergence of a new religious order. This may explain an increase in votive offerings along the shore.

A similar sea edge location has been identified for Mesolithic cemeteries. Mithen has noted a preference for coastal locations in the placement of cemeteries (1994, 120); a point also highlighted by Zvelebil's work (1986b, 172). Some burials were clearly located on islands surrounded by water or on promontories, where they would have been rapidly covered in water (Larsson 2003; Zvelebil 2003, 7, 10). In some instances, the dead may have also been placed directly in or on the water. This can be seen in the boat burial at Mollegabet II in Denmark dated to 5230–4960 cal BC, which was a period of rapid sea-level rise (Grøn and Skaarup 1991; 2004a and b). A similar practice can also be seen at the late Mesolithic cemeteries of Téviec and Hoëdic, which were located on promontories off the coast of Brittany but at a time when they were developing as islands (Schulting 1996).

These burials may represent further 'offerings' to the advancing shoreline or the inundating landscape may have been utilised to keep the spirits suppressed and away from the living. Evans (2003, 78) has suggested that Mesolithic cemeteries may have provided symbols of stability to contrast with their location on a changing coastline, which was a zone of instability. Certainly, the location of burials was likely to have been tied to ontologies of the land (as well as the sea). Blockley and Gamble (2012) suggest that the absence of burials in Britain during the environmental changes of the Younger Dryas was a response to the land becoming marginal during this period, possibly reflecting: "a loss of feeling for land … not frequently exploited" (2012, 185).

The practice of depositing axes within rivers appears to have been similarly prevalent throughout the Mesolithic, examples of which include the deposition of core axes in rivers in Scandinavia (Chatterton 2006), or tranchet axes and Thames picks in the River Thames (Field 1989). As described in Chapter 5, sea-level impacted far up rivers and into lakes and people would have perceived it so. Depositions in rivers and lakes may therefore be linked with sea-level rise. The practice of depositing human remains in rivers may have been widespread during the Mesolithic (Conneller 2006; Chatterton 2006); and animal bones and artefacts made from red deer antler may have been deliberately deposited into lake waters at Star Carr (Chatterton 2003; Conneller and Schadla-Hall 2003; Conneller 2004; Conneller *et al*. 2012). These practices may have been linked in the same way.

Similar practices likewise appear to be features of later prehistory (*eg* Bradley 1990; 2000), where burials and votive offerings are evident around the coast. A Neolithic burial dated to between 3632 and 3342 cal BC was recovered from peat beds between Hartlepool and Seaton Carew (Waughman 2005) and another buried with a small cache of flints was discovered in Walton-on-the-Naze, Essex (Murphy 2009; Warren 1911). Equally, the deposition of human skulls along parts of the River Thames in later prehistory has been argued as evidence for votive activity (Bradley and Gordon 1988). Neolithic offerings into wetlands are also known from Denmark (Koch 1999) and The Netherlands (Wentink 2007).

Bronze hoards are occasionally found in coastal locations, such as the bronze axe head and lumps of bronze from the Herra, a small promontory of land in Helford Estuary, Cornwall (Reynolds 2000). While fragments of Bronze Age boats found around the English coast, such as the Humber wetlands, the Severn Estuary and Dover, may also be seen as part of a structured depositional practice (Van de Noort 2011a). Bronze Age burials placed in watery contexts have been recorded in the Fenlands, while a Bronze Age cremation cemetery dating to between 1410 and 1060 cal BC as well as four bronze hoards have been recorded in Langstone Harbour, which at that stage was low-lying waterlogged grassland (Allen and Gardiner 2000). Similarly, round barrows built near peat bogs may represent monuments to the lost land (Evans 2003, 104).

Another example of Bronze Age ritual activity along the British intertidal zone is evidenced by the Bronze Age timber circle at Holme-next-the-sea in Norfolk ('Seahenge') arranged on a saltmarsh and dating to 2049 cal BC (Brennand and Taylor 2003). As well as the complex of timber alignments and platforms at Flag Fen near Peterborough, which was the focus for votive deposition. The stimulus for construction of the latter, according to the excavator, was "the steadily rising waters of the Fens to the north-east. The posts can, indeed, be seen as a symbolic weir or dam against their inexorable rise" (Pryor 2001, 431).

These practices, whether Mesolithic, Neolithic or Bronze Age, do not, however, necessarily have to be framed in terms of sea-level rise as an 'other' that needed pacifying. Instead, and more in keeping with the discussion in Chapter 2, it may be part of the process of mediation or negotiation with the landscape. As an alternative view, ritual deposition along the inundating shoreline could have been part of an on-going process to root people to that part of the landscape before it was lost. This may be particularly true of the coastal cemeteries, and perhaps we should see these as rooting people or returning them to their ancestral land.

Evidence from Goldcliff suggests that the shoreline was used as a defecation zone in the Mesolithic period (Bell 2007). In this way, rising sea-level would have removed this polluted space and therefore be seen as beneficial. As Douglas (1966) has emphasised, control of pollution plays an important role in the social life of modern groups, and it is worth considering the function of rapid sea-level rise in this. Votive depositions could, therefore, be perceived as a way of ensuring a continued rise and thus the permanent cleansing or mediation of the polluted zone.

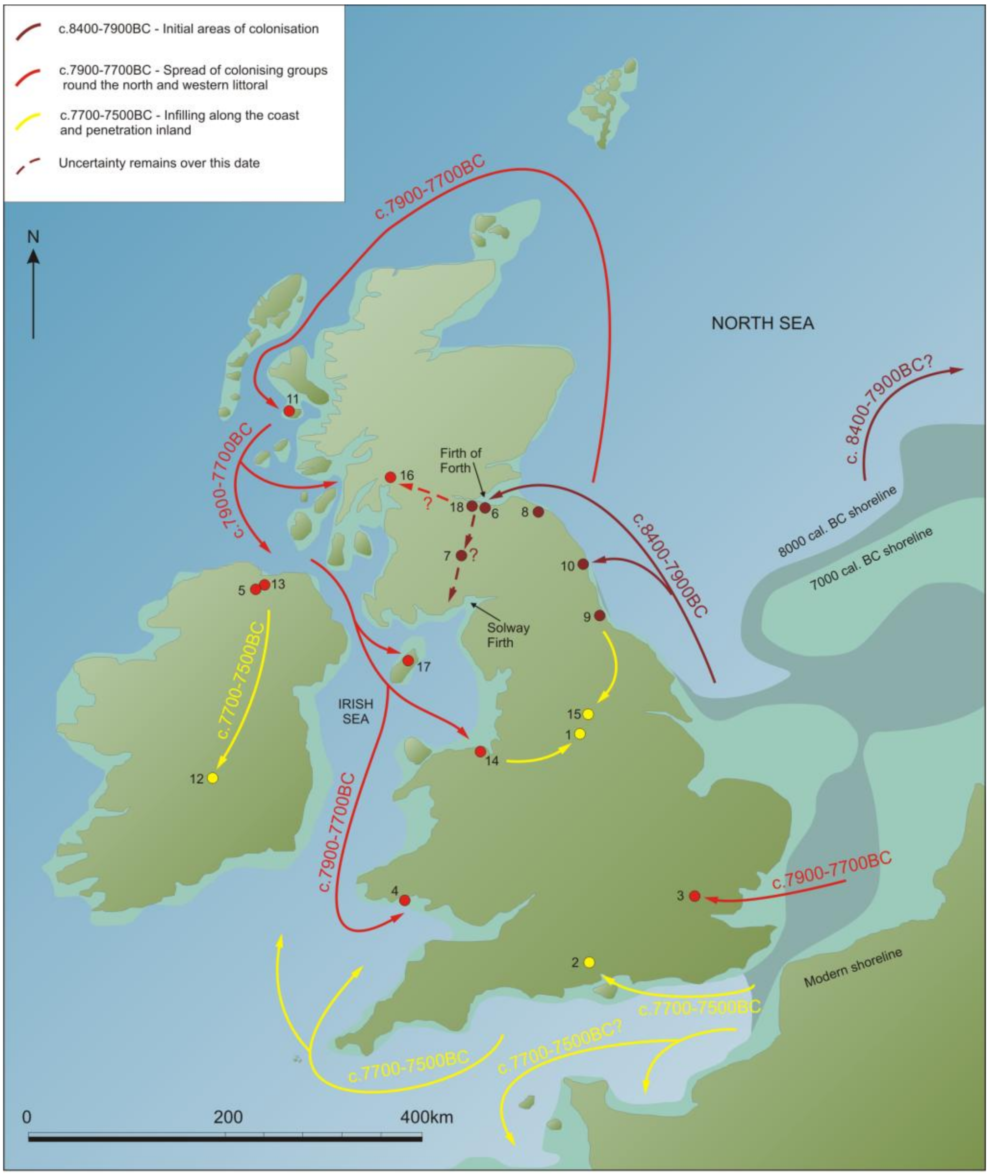
A similar case for the cleansing of a polluted land can be made for the siting of cemeteries in coastal locations. However these practices are to be interpreted, the advancing sea was likely attributed with agency and identity. And these practices may reflect the fact that the start of sea-level rise prompted a shift to a new relationship to this part of the landscape – a relationship that continued long after the Mesolithic period.

6.3 Mobility and migration

Mitigating the effects of rapid sea-level rise over a short time period would have included greater group mobility, including the ability to relocate temporarily and permanently. Migration or relocation of people away from Northsealand's submerging land is often suggested as an obvious and necessary response to the submergence of land with coastal groups forced inland (for example Jacobi 1979; Binford 1968; Price 1987). This would have been an on-going process throughout the period of sea-level rise, from the early Holocene to the end of the Mesolithic (see below). Migration from Northsealand has been suggested as responsible for population increases on terrestrial sites in Western Europe and consequent territoriality (Chapter 5).

Migration from Northsealand has been suggested as a reason for the colonisation of Scandinavian countries, such as Sweden (Schmitt *et al*. 2006; Johansson 2003). Passmore and Waddington (2012) argue that the spread of narrow-blade coastal settlements in the eighth and ninth millennia in Britain represents the movement of groups displaced by sea-level rise and the associated loss of land (Fig. 6.2). The lower density of earlier and over-lapping broad-blade sites in northern Britain possibly indicating "a relatively empty coastline for displaced groups from the North Sea Plain to colonise" (Passmore and Waddington 2012, 136). They speculate that this was followed by the spread of narrow-blade groups across Scotland and along the west coast of Britain to Wales and subsequently to Ireland (Fig. 6.2).

Coles (1999; 2000) has argued that Northsealand's displaced later Mesolithic community, highly adapted to a coastal lifestyle, may have provided a barrier, for a while at least, to the advancement of a Neolithic way of life. Turney and Brown, on the other hand and in a different area, suggest it may have driven the onset of farming across Europe (2007). Collard *et al*. (2010) similarly propose that agriculture was introduced to Britain through mass migration, although they do not link this to sea-level rise.



1 Broomhead Moor 5	6 Cramond	11 Kinloch	16 Midross
2 Broomhill	7 Daer Resevoir	12 Lough Boora	17 Cass ny Hawin 2
3 Broxbourne 5	8 East Barns	13 Mount Sandel	18 Echline
4 Caldey Island sites	9 Filpoke Beacon	14 Prestatyn	
5 Castleroe	10 Howick	15 Warcock Hill 3	

Fig. 6.2: Suggested movement of displaced narrow-blade groups around Britain. (From Passmore and Waddington 2012, 135).

Relocation is a common strategy amongst communities facing significant environmental change, again practiced at the individual and community level. At Shapwick Heath in Somerset a fundamental shift from the Mesolithic occupation of the lowland zone to upland areas is evident in the lithic and pollen record and linked to localised flooding (Bond 2009).

Mesolithic Iron Gates settlements along the Danube valley were abandoned between 6300 and 6000 cal BC and may have relocated to higher terraces. This period corresponds with the ‘8.2 kya cold event’, and therefore relocation could have been linked to extreme and unpredictable flooding events from the river (Bonsall *et al*. 2002a; Bonsall 2008, 265). Similarly, Fitzhugh (2012) describes how prehistoric hunter gatherers on the Kuril Islands in the Northwest Pacific adapted to tsunamis and intensive storm activity by moving settlements to high terraces and in more protected locations.

There are, however, other ways of framing migration as a response to sea-level rise and inundation. Migration is not simply an environmentally determined process and social aspects are also of importance in shaping the decision to migrate from one’s homeland. Holland Island in Chesapeake Bay, Maryland, USA, for example, was abandoned in AD 1920 following significant sea-level rise and loss of land. However, neither loss of land nor changes to natural resources were directly responsible for the abandonment, since the island remained habitable throughout the twentieth century. The island was abandoned due to loss of services, but more importantly due to a general loss of faith in a future on Holland Island (Arenstam Gibbons and Nicholls 2006). After abandonment the attachment to the island remained as people came crabbing in the summer for a number years afterwards, and reunions of former residents and their descendants still occur on the island. This suggests that social issues may shape responses to sea-level rise more profoundly than the direct impacts of environmental change (Arenstam Gibbons and Nicholls 2006).

The opposite is true of Funafuti Island, Tuvalu, in the South Pacific where today people choose to remain on the island. This is despite knowing that it will be entirely submerged within fifty years due to its low elevation and rapidly rising sea-levels (memorably described by Pearce [2007, 55] as "toodle-oo to Tuvalu"). Factors influencing the decision to stay include a sense of identity and lifestyle provided by the island, as well as a strong faith that God will protect them (Mortreux and Barnett 2009).

Although these examples clearly cannot be directly compared with prehistoric hunter fisher gatherers, they do serve the purpose of showing peoples' wide, and sometimes contrasting, responses to sea-level rise. They reveal that decisions on migration are frequently made on the basis of ontology as opposed to simple adaptive responses.

In the area of the North Sea, islands permanently occupied by communities may well have been abandoned long before they became uninhabitable. A study of the southern Hebrides, for example, revealed an absence of settlement activity on the islands of Islay, Jura and Colonsay between 6050 and 5050 cal BC (Mithen 2000). This is a period that saw a rapid rise in sea-level, of the order of 6.5 m over 100 years. Landscape changes would clearly have been evident "during the lifetime of one individual, and certainly that of two or three generations" (Mithen 2000, 622). Although these islands remained habitable during this time, the period of abandonment (which coincides with the rapid rise) could be seen as a reflection of a loss hope for the future of the island. As Mithen (2000, 622) points out "a Mesolithic forager may well have believed that the sea level was set on a course of continuous rise”. Another group on a different island were just as likely to have responded entirely to the contrary.

Islanders will also have had ways of coping for a while. People on Tikopia, a small island in the Solomon Islands, for example, have coped with cyclones until recently. They have done this “by migrating temporarily to other islands and by keeping their population size at a level that would allow a margin of survival during times of critical food shortage” (Torry 1978, 175). Strategies employed to keep the population low included use of infanticide, abortion, marriage restrictions and allowing individuals to take suicide voyages out to sea.

There are no clues in the archaeology as to who had the authority to make decisions about when a community moved and to where, or who led migrations from submerging land, although it is an interesting point to consider. Following abandonment of a Northsealand island, communities perhaps returned to islands by incorporating them into their subsistence strategies. This may have been to collect particular food sources, hunt seals, gather shellfish, or to procure lithic raw material, as well as to maintain an ancestral attachment.

Equally, groups may have clung on to a life on the island through a sense of place and identity long after it had become clear that it was being swallowed by the rising tide; a process that may have continued into later prehistory. Rising sea-level throughout the Mesolithic period could have led to the continual movement of people further inland or to higher ground, or perhaps prompted widespread maritime dispersal (see below; also

Oppenheimer [1998] provides a speculative discussion of prehistoric migration as a result of sea-level rise in Southeast Asia).

6.4 Information and knowledge

Perhaps the single most important strategy for enhancing resilience to a changing environment is being informed. This is a process that would have again developed over a long time period (multiple generations), but could have been implemented quickly during a period of rapid rise. Having innate hazard awareness and a good knowledge base enables people to identify what is happening and to know how to respond (affordances in Gibson's terminology). This is particularly important for responding to the effects of sea-level rise, since it allows intergenerational communication about events or processes which may only become evident over extended periods. Further, the availability of information about changes and risk clearly influences people's decisions and motivations for adaptive strategies. Knowledge is itself empowering, but it can also be restricted, controlled and traded more widely.

Social memory

Encoding a variety of terms for recognising changes to the landscape within language or art can be a way of precisely and accurately communicating information and observations, and may well have been used to pass on information of sea-level rise in the Mesolithic. Informal knowledge systems, such as storytelling, myth, folklore, ceremonies, music and artistic representations, provide a highly effective way of encoding environmental information and transferring knowledge of appropriate responses over long periods of time.

This can include information about how to deal with, and what to expect from, the changing coastline, as well as ways of expressing human emotions to the loss of land. Or even ways of keeping destructive, and perhaps tragic, events alive in people's minds. They can also act as a creative cue for thought about future decisions. As Payson Sheets points out, literate societies underestimate "how non-literate societies convey disaster knowledge, hazard recognition, and proper behavior from one generation to the next" (2012, 44).

In this way, experience of the realities of environmental change becomes built into social life and forms part of a worldview. This is demonstrated by the inhabitants of the Papua New Guinea Highlands who had a strong oral tradition of the AD 1660 Long Island volcanic eruption long after the event (Gratton 2006). Hsu (2000) outlines a number of Chinese myths, poems and songs relating to climatic fluctuations and flooding events that are full of pragmatic advice. It has also been suggested that Australian aboriginal art preserves memories of sea-level rise from between 7000 to 5000 cal BC (Flood 1983, 143). Krajick (2005) suggests that encoded myths have given societies knowledge for behaviour and thus saved lives. For example, he suggests the Moken people of Thailand knew what to expect and what to do at the first sign of the AD 2004 tsunami (sail out to sea and meet the wave early) and as a result almost all survived. Minc and Smith (1989) describe how Tareumiut and Nunamiut hunter fisher gatherers in Alaska encode information in their oral traditions so that:

> “when wolves starve on land they go to their relatives in the sea and turn into killer whales; conversely killer whales, when unable to find food in the sea, travel inland and become wolves. Similarly, mountain sheep are thought to wander down to the sea to become beluga. Thus, it is known that when there are plenty of beluga off the Arctic coast, mountain sheep will be scarce and when sheep are plentiful in the Brookes Range, beluga are absent in the adjacent coastal regions” (Minc and Smith 1989, 20).

Correspondingly, it has been suggested that some Palaeolithic art contained or embodied information about environmental change. Depictions of animals, their tracks and their habits (such as mating and defecation) may have been a way of broadcasting knowledge of the animals that informed hunting strategies (Mithen 1990; Cook 2013). In this way, it allowed others to cope better with the harsher conditions of the Last Glacial Maximum and dwindling animal resources. Mesolithic mobile art may have similarly passed on abstract and symbolic information. Zvelebil has suggested that certain decorated artefacts with particular motifs in the Mesolithic may have represented “a grammar of communication” and elements of “information pathways” (Zvelebil 2011, 197). Objects such as these may have been related to myths, perhaps allowing people to unlock information about sea-level rise and past climates. This is in much the same way as the Mande people of West Africa use terracotta figurines to “curate and transmit both past environmental states and possible responses to them” (McIntosh *et al.* 2000, 24). Bengtsson (2003) has suggested that Lihult adzes carried information about territorial cohesion across parts of southern Sweden.

Similarly, Gendel (1987) argued that the shapes of microlithic points in the late Mesolithic of northwest Europe encoded information on territories.

> "People's explanations of disaster tend to rely on creative, often mythological imagination. The belief systems of people experiencing or expecting calamity are rife with symbols dealing with their situation, and their cosmologies are vibrant with metaphor" (Hoffman 2002, 113).

In this way, earthquake-induced tsunamis along the northwest coast of North America have been framed in myth as a battle between a great whale and a thunderbird (Krajick 2005). In areas where disasters occur frequently, life may become regulated by taboos, well illustrated in Maori culture: "exposed to frequent volcanic activity in North Island, Maori culture appears to have adapted to the hazard by establishing tapu (taboo) over areas which were clearly at risk" (Gratton 2006, 15). These myths can order and make sense of a disaster and perhaps also have a therapeutic effect. As Hoffman (2002) has observed:

> "but the cathartic value of disaster symbolism is even more primary. The imagery surrounding disaster implements cultural and personal survival. It provides a compass of orientation on how to think about calamity and gives an orbit of persuasion on how to cope with and survive it. Behind the symbols lies a logic that classifies the event and gives it cause" (Hoffman 2002, 114).

Ideologies may portray very sudden environmental change as the result of some sort of social wrongdoing, for example the biblical story of Noah and the flood, or the AD 1607 tsunami or storm surge in the Bristol

Channel and Severn Estuary (Fig. 5.5 in Chapter 5; Haslett and Bryant 2004), interpreted to be God's warning to the people. The AD 1755 flood on All Saints Day in Lisbon was similarly framed as punishment for sin (Bell and Walker 2005, 173), (and see discussion of similarly interpreted floods in Chapter 7).

Togola (2000) suggests that for the Mandé of West Africa: "environmental crises, indeed all kinds of calamities, are not seen as natural phenomena. Rather, they occur as the consequences of people's or spirits' malevolent acts" (2000, 187), (also Echo-Hawk 2000). Others simply honour the event, such as the Mandan Indians in Missouri who hold an annual ceremony to commemorate 'the great flood', which includes a representation of the first man, Nu-mohk-muck-a-nah, who relates the flood story (Matthiessen 1989). With an interesting link back to the above discussion on ritual deposition, the final part of this ceremony involves collecting a pile of axes from the villagers and disposing of them in a deep part of a river (Matthiessen 1989, 152–4; Field pers. comm.).

These narratives, therefore, order both diachronic and synchronic events and give them reason, and such symbolism may include beginnings and ends or apocalypse and revival. Disaster ideologies often rotate in cyclical fashion, especially when environmental change is chronic, thereby making the unexpected expected; "calamity does not imply loss, for all returns" (Hoffman 2002, 134).

By explaining, justifying and demystifying environmental change in this way, it becomes possible for people following social rules to come to terms with the changes, and perhaps in some extreme circumstances to ignore the risks facing them. This may include culturally conservative groups that are unwilling to adapt to the changes facing them, such as the reluctance to abandon a shrinking island or to migrate from one area to another (an approach adopted by Tuvalu islanders). In a similar vein, Coles (2000) discusses how culturally conservative North Sea islanders may have resisted the adoption of agriculture, thus preventing its broader adoption on mainland Britain.

Oral traditions are clearly an important way of passing information on. This is similar to what McIntosh *et al*. (2000) have described as 'social memory'; the repository for captured experience and accumulated knowledge of change, and the arena in which ontologies of the world were formed, and adaptations formalised. The point that certain hunter gatherers retain considerable information about their environment beyond simple economic needs has been made for both the Nunamiut (Gubser 1965, 242) and the Koyukon (Nelson 1983, 136), and suggested to be a "risk-buffering strategy of storing information that may be of use in the future" (Mithen 1990, 74). Similarly, Mithen suggests that late Upper Palaeolithic cave art was a way of transmitting information and part of "the process of adaptation to their ever-changing environment" (Mithen 1990, 255).

Accumulated knowledge and resilience

Adapting to sea-level rise and the associated land and resource loss could have been significantly enhanced by a detailed knowledge of the local environment. Indeed watching, understanding, interpreting and predicting the weather is a vital activity and an integral part of daily life in many modern societies, and the more precise one's observations are, the better the forecast.

In the Arctic, watching the weather is a respected task and people spend hours scanning the horizon and discussing indicators (Krupnik 2002). People, environment, birds, animals, plants, beliefs, and weather are interrelated, and in ceaseless motion with one another. Relationships are drawn between temperature fluctuations, wind strength and direction, wave energy, people's safety, animal behaviour, vegetation growth, and hunting success. People have a finely-tuned awareness of these ever-changing relationships and learn to predict the weather, read the terrain, judge the conditions, and predict animal movements and distributions. It is through many years of mentoring with elderly experts that one learns to combine personal experience with generations of observed correlations between weather, land, sea, and animals, and this in turn increases resilience to change. It helps people to construct knowledge of how to deal best with their changing environment. In this instance, knowledge of the weather is not simply handed down through generations as a cultural package, but is accumulated. It "grows through a lifetime's experience of living in a place and moving in its environs" (Ingold and Kurtilla 2000: 187).

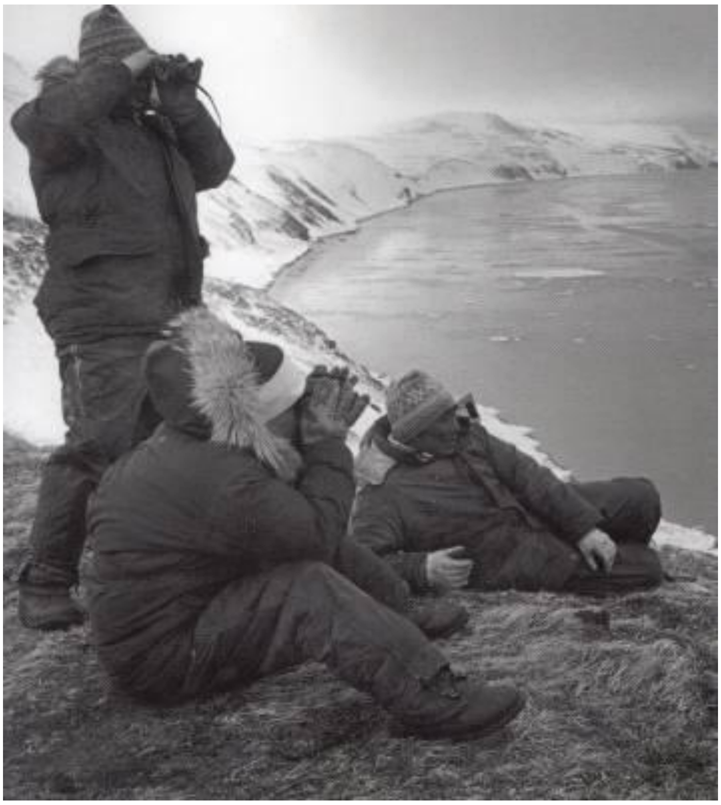


Fig. 6.3: Studying ice conditions in Toksook Bay, Alaska. (From Krupnik and Jolly 2002).

Without drawing a direct parallel between the Mesolithic groups of Northsealand and Arctic communities today, it is likely that knowledge of the Mesolithic environment, and any changes to it, were accumulated through a similar experience of engagement. Through continuous observations and daily encounters with the environment. The same point has been made by Mithen (2000) who points out that Mesolithic sites in the southern Hebrides are mostly located with good views across the land:

> "in general, the selection of sites with good viewsheds should not be surprising. Hunter-gatherers rely on information about their changing landscape: they constantly, informally and to some extent unconsciously, monitor the movement of animals and birds, the changing skies and light conditions. The Mesolithic people in the southern Hebrides would have been naturalists par excellence" (Mithen 2000, 605).

Through such deep phenological data, people could have developed a detailed knowledge and sensitivity to changes in the environment: an understanding of when thresholds were likely to be breached, the significance of dead woodlands, and the likely effect on resources and territory size. Appropriate responses could then have been formulated. These may have included avoiding areas vulnerable to flooding or collapsing cliffs, or knowing where the higher, safe areas are. They may also include making changes to subsistence patterns or adjustments to the timing of the seasonal calendar, modifying their hunting locations, or exploiting a mix of species, and thereby minimizing risk and uncertainty. By *actively engaging* with their surroundings and monitoring the environment, Mesolithic hunter fisher gatherers could build an *accumulated knowledge* of their changing environment that then increased their *resilience* to the changes taking place.

By continually taking a measure of the changing (unfolding) landscape and of the situation, emotional responses are created. As set out in Chapter 2, emotional responses are important to the way people perceive, understand and interact with the world, and are motivated into action (Johnson 2007; Damasio 1999; 2003; 2012). As Johnson puts it: emotions "are, in fact, one of the most pervasive ways that we are continually in touch with our environment" (2007, 67). To emphasise a point made previously: responses to environmental change are not simply economic efficiency, but are formed through a constellation of understandings, ontologies, perceptions and emotions.

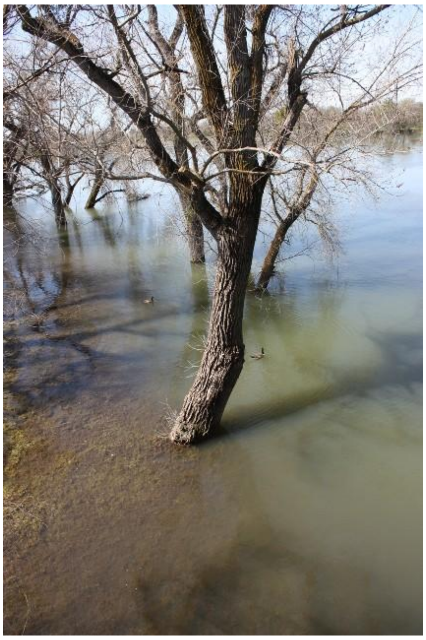


Fig. 6.4: A flooded landscape in California, USA. (Photograph by author).

6.5 Social networks and exchange

Critical to effective information flow are vibrant social networks. Enhancing these can improve a group's ability to deal with change by offering access to resources unavailable locally, or improving understanding of the changes through information exchange (Whallon 2006; Zvelebil 2011). Again, this is a response that would have developed over a long time scale.

In the Mesolithic the circulation of, say, beads as body adornments (Simpson 2003), or stone raw material may represent part of a broader network of maintaining social relations during periods of rapid inundation. Indeed, almost all Mesolithic beads in Britain are connected with the sea or the shore, *ie* shells, beach shale or amber (Conneller pers. comm.). Portland Chert was clearly caught within such a network (Care 1982), found on Mesolithic sites from as far afield as Cornwall to the west and at sites such as Broomhill in Hampshire to the east (Chatterton 2006).

The Severn Estuary attests to contact up to 100 km away (Bell 2007), while Mesolithic lithics recovered from Priddy in Somerset may have derived from 40 km away (Taylor 2001). Hind (2004) has demonstrated the movement and circulation of chert artefacts and raw material around the Peak District, Derbyshire, in the late Mesolithic. He suggests that they may have had potency and symbolism and were caught within an exchange mechanism, and that their value may have been as a medium for information exchange. Similar exchanges around coastal areas may have provided the medium for the exchange of information on rising sea-levels. Further afield, at Hardinxveld in The Netherlands the raw material suggests contact with areas as far as 160 km (Louwe Kooijmans 2003).

Mesolithic exchange networks in southern Scandinavia have been well studied (Larsson 1988b; 1990b; Strassburg 2000; Zvelebil 2011), highlighting the role of figurines, pendants, star-shaped picks and decorated bone and antler objects. The distribution of axes in Denmark suggests contact with areas 50 km away (Fischer 2003). Exchange networks have been put forward as the reason for the distribution of Ertebølle shoe-last adzes in Sweden (Edenmo 2009), as well as Lihult adzes across arts of southern Sweden (Bengtsson 2003). Imported finds at Ertebølle sites indicate a certain amount of exchange with farming communities (Hartz *et al*. 2007). Danish portable art has been suggested as providing evidence for exchange systems (Zvelebil 2011), and compared with the 'Kula Ring' (Nash 1993). Certainly artefacts with certain dominant motifs, such as the 'wheatsheaf' design, are distributed widely across Jutland and Zealand and the archipelago of islands during the Mesolithic. Mesolithic period exchange has also been widely discussed with regard to the circum-Baltic region more broadly (Zvelebil 2006; 2011), central Europe (Kind 2006), and south-east Europe (Voytek and Tringham 1989).

If one accepts that certain Mesolithic objects were part of an exchange system, they would have created alliances and obligations, and established communication between groups, strengthening bonds. It could also have structured marriage relations, so that exogamous interaction and the exchange of objects and information were part of the same network. This has been suggested to have occurred in Scandinavia in the Late Mesolithic; a process which may have led eventually to knowledge and the spread of the Funnel-beaker culture (Hallgren 2003; Larsson 2007). Similarly, inter-group marriage networks have been postulated for south-east Europe (Chapman 1989) and western Europe (Constandse-Westermann and Newell 1989). In coastal areas, information exchange concerning sea-level rise may well have formed a part of these exchange networks.

The Chumash maritime hunter fisher gatherers in California, to take a different example, developed strong social networks and alliances with groups from different environmental zones during the Medieval Climatic Anomaly, in order to share resources and therefore increase resilience to fluctuations (Johnson 2000). As an interesting link with the British Mesolithic, they also increased production of shell beads during this period in order to exchange within these broader networks (Johnson 2000). Minc and Smith (1989) describe how Tareumiut and Nunamiut communities in North Alaska frame food shortages as socially-generated and requiring social mediation. This takes the form of an expansion of social networks, thus gaining access to a larger resource base.

Some women in the Red River Valley, USA, following a major flood in 1997, drew on extended networks to share hazard information, make contingency plans and organise “care of the young, old, sick and disabled” (Enarson 2001, 6). Few *et al*. (2004a) suggest that following a sudden flood, responses should have an emphasis on social intervention such as:

> “improving the flow of information to the public on the disaster and the response; organizing shelter to keep families and kinfolk together; discouraging unceremonious disposal of corpses; re-establishing cultural and religious events; facilitating inclusion of orphans, widows and widowers in social activities; offering activities for children; involving people in purposeful and common interests; and disseminating information on normal reactions to stress” (2004a, 72).

Emotional support from within households can be a coping mechanism, and Deering (2000) stresses the strong role that parents and significant adults play in conditioning children’s response to modern flood events. “Providing emotional support for children is key, through activities such as comfort, reassurance, restoring routine and talking through events” (Few *et al*. 2004a, 52).

Of course, social networks are easier to maintain when population densities are higher and settlements are closer together. This may mean that communities that lived on islands in Northsealand that were becoming increasingly cut-off may have experienced social isolation, making it difficult to maintain such networks.

6.6 Flexibility, diversification and intensification

A pragmatic response to rapid environmental changes includes being flexible. In the Mesolithic this may have included being able to move quickly to exploit any positive opportunities that might arise, as well as to monitor ecosystems and resource stocks. As described in Chapter 2, the environment is constantly fluctuating, with resource abundance one year and scarcity the next. Irregularity is a fundamental of the environment hunter gatherers live in, and responses to deal with fluctuations for resource procurement are a necessity of life. It is likely that Mesolithic communities lived within relatively fluid lifeways, which would have been highly resilient to environmental changes.

Other ways of being flexible and adapting practices specifically to sea-level rise may include strategies such as locating freshwater sources away from inundating zones to avoid contamination from saltwater. This may have included the digging of water holes or wells, similar to those recorded at the Mesolithic site of Friesack, Brandenburg in Germany, dating to 7750–7500 cal BC (Gramsch 1998).

It may include an altered temporality, so that resources were used at different times of the year. Åkerlund suggests that Mesolithic communities in Sweden developed “flexibility for coping with unstable, continuously changing conditions” (Åkerlund 1996, 127). This is not to suggest that Mesolithic individuals were passively flowing with the environment, but that they were faced with a multitude of choices, which were adopted as appropriate to the individual circumstance.

Rowley-Conwy and Zvelebil (1989) suggest that storage is a possible Mesolithic response to periods of short-term fluctuations; a feature that is “by no means incompatible with nomadic movement” (Ingold 1983, 560). Seasonally abundant plant foods like acorns or hazelnuts are easily storable and rich in calories; whilst, fish, such as salmon, can be smoked for later consumption. Although identifying storage in the archaeological record is not easy (Kuijt 2009; Morgan 2012), a possible example may be detectable at Mount Sandal where posthole arrangements have been interpreted as possible fish drying or storage racks (Woodman 1985). Pits filled with hazelnut shells in the southern Hebrides, Scotland may attest to storage pits (Mithen 2000). And large cylindrical pits have been interpreted for storage at the Mesolithic settlement of Auneau, France (Verjux 2003).

It is not unreasonable to assume that this was a familiar practice throughout the Mesolithic. Voytek and Tringham (1989) have suggested that storage was central to the late Mesolithic economy of the Iron Gates in the Danube valley, arguing that the stone-lined pits, usually interpreted as hearths, were used for storage. This may have been a response to periods of cooling and flooding, such as the ‘8.2 kya cold event’, which would have affected, for example, fish migrations (Bonsall 2008). Rowley-Conwy and Zvelebil (1989) also discuss the storage of prestige items for trade and exchange during lean years, terming this ‘social storage’. In this way, responses to the changing environment may have involved the intensification of certain resources, both economic and social.

Hand in hand with intensification is diversification – possibly because intensification leads to fluctuations in yields requiring the exploitation of a greater range of species to make up the occasional shortfall (Mithen 1990, 247). There are certainly considerable benefits in diversifying resource and subsistence strategies, or by turning toward more readily available but perhaps less favoured foods. As Rowley-Conwy and Zvelebil (1989) point out: "diversification is widely practiced by hunter-gatherers and provides a cushion against variability in individual resources" (1989, 44).

Off the Baltic coast, for example, Ertebølle settlement evidence suggests a shift from terrestrial resources and freshwater fish to progressively greater exploitation of marine resources (Lübke 2009; Zvelebil 1989). Elsewhere, however, a shift in subsistence strategies towards a broad spectrum of resources during a period of rapid environmental change in the Mesolithic has been suggested, for example at Grotto del'Uzzo in north-west Sicily (Mannino and Thomas 2009) or in the Italian Alps (Grimaldi and Flor 2009).

Similar examples from around the North Sea basin no doubt exist. Intensification and diversification leave little archaeological trace, but as Milner points out, "from the data we have it should be possible to identify interesting differences in diet and consumption practices within regions and across wider spatial and temporal scales" (2006, 73). And it is interesting to consider what the archaeological record of such diversification would look like.

Diversification as a way of responding to environmental changes can be seen in a very wide range of examples from across the globe and from different times. Cooper (2012), for example, highlights how the faunal assemblages from archaeological sites in the area around Los Buchillones in the Caribbean evidence diversification of food resources from a range of environments. He suggests that this represents a resilient strategy against sudden disruptions to local environments, including sea-level rise. Nelson *et al*. (2012) suggest that in prehispanic central and northern Mexican settlements crop diversification was a risk-buffering strategy against environmental uncertainty, whilst other strategies may have included concentrating water resources through irrigation or terracing, food sharing, mobility, and crop storage. A modern example of diversification includes farmers in Maheshkhali upzali on the southeastern coast of Bangladesh who have turned from traditional agriculture to salt and shrimp farming to cope with heavy salinity intrusion (Akter 2010).

Imposing restraints, quotas or even taboos on certain resources may also be a way of protecting them for the future. Indeed, looking ahead and nurturing resources in general is a resilient strategy, as well as the sharing of resources between and across communities. Risk is therefore spread across a diverse set of activities. Flexibility and diversification again occurs at the local level.

In recent times, an adaptive strategy by farmers in Maheshkhali upzali, Bangladesh, has been to actively conserve mangrove forests to help protect the shoreline against coastal erosion (Akter 2010). While at first glance actively conserving an ecosystem in the Mesolithic period seems an unlikely response, it is not impossible. There is growing evidence for a greater manipulation of the environment towards the later Mesolithic (*eg* Simmons 1996), including evidence from fish traps for woodland management such as coppicing and pollarding (McQuade and O'Donnell 2009; Pedersen 1997). This is usually seen in terms of enhancing economic productivity (improving the growth of particular forms of vegetation to attract wildlife as prey, *etc*). However, it is worthwhile to think of the possibility of active conservation being used in coastal zones as an adaptive strategy against sea-level rise.

6.7 Technical and technological adjustments

There were also likely to have been technical responses to sea-level rise in the Mesolithic. These will have occurred both rapidly, *ie* to deal with an immediate event, such as flooding, as well over longer time scale, *ie* adaptations to technology. To take an example of a rapid response – in areas prone to flooding people may have made adjustments to their dwellings to counter the incursion of floodwater or to prevent exposure and injury when floods enter. At Timmendorf-Nordmole I in the Wismar Bay, for example, a line of 'stepping stones' had been placed on waterlogged ground between the Ertebølle settlement and the shore (Lübke 2009, 560). Further afield, the Mesolithic buildings at Lepenski Vir, Padina and Vlasac along the Danube valley (dating to between 9250–7500 cal BC) (Radovanović 1996, chapter 3), exhibit a number of rebuilds and internal reorganisations. These may represent responses to damage caused during periods of extreme flooding as a result of climate change (namely the '8.2 kya cold event') (Bonsall *et al*.

2002a; Bonsall 2008). It has also been argued that the limestone floors at the site were a way of creating permanence in dwellings damaged by this postulated flooding of the Danube (Borić and Miracle 2004; Bonsall *et al*. 2002a).

In studies of modern communities living in the Mekong Delta in Vietnam, Few *et al*. (2004b) list a number of household coping actions. These include avoidance of exposure to water in houses by raising furniture on bricks and creating raised walkways from planks, as well as the removal of unused vessels where mosquitoes can breed after flooding has receded. The internal layout of houses in low-lying coastal areas could be adapted to militate against occasional flooding, by raising or suspending floors. Practical techniques may also have been used to warn of sudden floods; a traditional coping mechanism in northern Pakistan, for example, is to tie ropes with bells across rivers to provide warning of a flash flood (Davis and Hall 1999).

Flint sources would have been cut off and submerged as a result of sea-level rise (Chapter 5), impacting at a local level what flint was used, the way it was used and the flint tools themselves. Indeed, tool changes have often been couched in terms of adaptations to the changing environment, usually suggested as a result of changes in the availability of game (Eerkens 1998; Jochim 1989; Myers 1986; 1989; Torrence 1989a; 1989b; 2001), despite Rozoy's (1989) comments to the contrary. Since tool changes occurred over broad areas this assumes that environmental changes must have occurred in equal force across wide regions, impacting everyone in the same way. But as we have seen, sea-level rise was not invariable; it affected regions differently, some in extreme ways and others not at all, and over different temporal scales. Further, people are affected differently by the same changes. An argument that sees technological change driven purely by environmental change presumes an objective environment constraining human behaviour.

It is worth exploring this point a little further, as there are different ways of understanding widespread tool changes. As Appadurai (1986), Gell (1998), Dobres (2000; 2001), Dobres and Hoffman (1994), Ingold (2006; 2007) and many others have argued, artefacts are active in the social world. And some scholars have explicitly applied this approach to hunter gatherer artefacts and materiality, for example Conneller (2011) and Cobb (forthcoming). As Robb (2004) has pointed out, this notion was one of the earliest canons of post-processual archaeology (for example Hodder 1982). It has been suggested that objects help to extend "the embodied self out through a network of material culture" (Gosden 2004, 36); the 'extended artefact' as Robb (2004) calls it. Objects, then, are not isolated but part of a broader, extended concept. They are widely distributed and are entangled with the whole environment, including people. "It is in their connections, and in their flows into other forms, that their thingness resides" (Hodder 2012, 8). Furthermore, tools are made within a particular praxis – a cultural setting or *habitus*, learned through an active engagement with the people around them (Ingold 2000; Bourdieu 1977). These perspectives usefully place focus on the process of making as well as the materials used, and draws us away from approaches that see technological change as a straightforward environmentally-driven process.

6.8 Experimentation, innovation and creativity

While the effects of sea-level rise would clearly have posed some challenges in the Mesolithic period, it would also have offered new opportunities, and sea-level rise does not have to be viewed as a negative in every respect. Experimentation, innovation and creativity would have increased the number of choices available to a group and are possible responses to the changing land, and this may include for example the adoption of farming (Bonsall *et al*. 2002b; Tipping and Tisdall 2004; Turney and Brown 2007). Such an example illustrates how climate change may have provided opportunities for social, technological and economic change. Although innovation should not be seen as necessarily the outcome of external factors alone.

A response to sea-level rise and the loss of land may have been to adapt to the seas in a far more intimate way. If, as suggested in Chapter 4, the coastal inhabitants of Northsealand were already closely identified with the sea, inundation of the area may have been positive. A perception of a widening sea may, therefore, have predominated rather than a loss of land. This sees the inundation from a maritime perspective (a 'maritime turn' – Van de Noort [2011a]). This inversion of perspective places emphasis on the sea as somewhere to inhabit, much like the Saltwater People mentioned in Chapter 4. A similar inversion of perspective may well have been created during the flooding of the Northsealand. As such, people displaced by sea-level rise may not have had to compete with other groups further inland, but instead spent the majority of their time at sea (Bjerck 2009; Wikell *et al*. 2009).

The inundation of Northsealand may well have encouraged people to take to the sea to visit traditional areas or make contact with distant relatives cut off as a result (Field 2008, 87). In this way people may have identified with the sea, and become identified by their relationship with it. The loss of land in the early Holocene as a result of sea-level rise could, indeed, have led to some of the first sea-faring groups in the British Isles.

6.9 Chapter summary

Responses to environmental change are highly complex and very difficult to document; there is no simple linear relationship between changes in the environment leading to a particular set of adaptations. As outlined, adaptation is in reality a continual course of changes in order to adjust lifeways to a constantly changing world; it is an *ongoing process*, not a final state.

Grothman and Patt (2005) suggest that peoples' perceptions and observations of environmental change risks are the main determinants of adaptation. That is to say that people operate in an environment as they see it, and it is through this perception that responses are developed. As Gibson and Pick (2000) contend: "perception guides action in accord with the environmental supports or impediments presented, and action in turn yields information for further guidance, resulting in a continuous perception-action cycle" (2000, 16). This bottom up approach focuses on the local-scale and particularly local-scale decision-making (discussed in Chapter 3). Responses, by necessity, are local in scale, and people adapt, reorganise and adjust at an individual, household or community level (for example Akter 2010; Gbetibouo 2009; Osbahr *et al*. 2008; Grothman and Patt 2005).

Further, there are different motivators and barriers that influence responses and these may include social norms and networks, gender, class, or ethnicity (Osbahr *et al*. 2008). Differences would have occurred between communities, so that some communities would have been better placed to adapt than others. That is, they may have had greater access or entitlements to resources, better adapted to exploit terrestrial resources, or have advantageous social networks. Differences would have occurred within communities too, for example some people would have been more skilful or more experienced than others and therefore likely to have taken advantage of certain situations more quickly. It is also worth noting that the environment affords some things but not others, and people are always tied to praxis and a particular historical environment where some things are possible but others are not. In this way, choices available were not unbounded.

Nevertheless, a wide array of responses to sea-level rise could have been available to Mesolithic communities according to the *habitus*, *eg* a predisposition to certain responses, and this chapter has highlighted the variability of these. Dillehay (2012) emphasises this point in his discussion of Late Pleistocene and early Holocene Peruvian sites, showing that whilst some groups evidently adjusted socio-cultural traits during periods of climate change, neighbouring areas did not. Choices were available and local groups responded differently deciding whether or not to change, move or maintain the status quo. This is because chosen responses are local or regional in scale, and decisions are made at the individual, household, or community level.

The overwhelming evidence from climate change literature is that adaptations and decisions on adaptive strategies occur at the individual and household level; that is to say, at the local scale. They are made by those directly engaging with the environment, with local knowledge of the environment and changes and traditional ways of coping with them (Chapter 3).

This chapter has discussed a selection of possible responses based on a diversity of information, highlighting the complexity and multiplicity of choices available. Flexibility is essential to cope with variability, whilst diversification and intensification can enhance resilience. Responses, however, are not inevitably related to explicit resource strategies, and may well have included intensified ritual activity in affected areas. A fairly obvious response to the submergence and loss of land is migration; however, again this is complex and to some degree socially determined.

This chapter has also emphasised the role of information and knowledge, particularly an awareness of the hazards and appropriate responses to them. Communication and good social networks are essential for an effective response, particularly to sudden catastrophic events. How experimentation, innovation and creativity may also have been a feature has also been discussed.

Responses are conditioned by perceptions and understandings of the material world, and agency. They also comprise choice – the choice to do this over that, or to go here rather than there. These choices, made on the ground and based on knowledge acquired from the wider community, as well as personal experience of the environment, can vary according to changes in the environment, and perceptions of the environment. People learn about the environment and any changes to it as they go and from past events, and through this attunement can prepare themselves to cope better with future changes and events.

By relying on a perpetual monitoring of the current situation, hunter fisher gatherers are able to gain information on changes to the environment, however subtle. They thereby make themselves resilient to, or even taking advantage of, these changes as they arise. Adaptations are, therefore, not rational decisions imposed by environmental changes, and there is no simple cause and effect between them.

Although a number of themes have been discussed in this chapter, the reality would have been messy, entangled, interrelated hybrids of these, with many more that simply cannot be guessed. And the consequences are just as likely to have been unintended as intended.

Chapter 7

Epilogue: The remembered land

"Humber, Thames: Variable 4, becoming 5 or 6 later. Rain and fog. Poor or very poor. Tyne, Dogger: Variable 4, becoming south or south-east 5 to 7, perhaps gale 8 later. Rain, fog patches. Moderate, occasionally very poor. Rockall, Malin, Hebrides: South-easterly gale force 8 increasing to severe gale 10, veering south 5 to 7 later. Rain or squally showers. Good occasionally poor. South-east Iceland: North-easterly gale force 8, perhaps severe gale 9 later. Wintry showers, rain later. Good, becoming moderate or poor". The shipping forecast issued by the Met Office, Radio 4, 13/04/2013.

7.1 Introduction

Standing on the Norfolk coast now and staring out across the North Sea at the seemingly endless expanse of water, the turbines on the horizon looking like toys placed by a playing child, it is easy to forget that this water overlies a once terrestrial landscape. Not just a land bridge that people journeyed across, but home to generations of people, a land of places and names and mythologies and where lives were played out in all their exhilaration. It is also interesting to speculate how the encroaching seascape was understood and perceived by later communities.

This final chapter very briefly outlines possible ways people in later prehistory and in the historic period perceived, engaged, and responded to the new sea, and its power to give as well as to take. The chapter then outlines the main points from the thesis and discusses ways to move studies of sea-level rise and Northsealand forward. It ends on a short narrative piece.

7.2 Land and sea in later communities

Sea-level rise slowed down considerably from the beginning of the Neolithic period (from around the fourth millennium BC). Although there was a general background of rising sea-levels, these fluctuated greatly with a series of transgressions and regressions (Fig. 1.8 in Chapter 1). Offshore evidence for the continuing rise of sea-levels comes from the river channel recorded opposite the Humber and Wash estuaries by the Humber REC (Chapter 4, Fig. 4.2g in Chapter 4), which was inundated between the end of the fifth and into the fourth millennium cal BC (Gearey *et al*. forthcoming).

Land along the coastline continued to be inundated, and in the Fenlands a number of Neolithic sites, such as Shippea Hill (Clark and Godwin 1962; Smith *et al*. 1989) and Hurst Fen (Clark 1960), were affected by rising water levels. The associated changing landscape in this area would have been both highly local and, at times and in places – rapid (Sturt 2006). The Blackwater and Crouch estuaries on the Essex coast also saw marine transgression in the later Neolithic period resulting in forest die-back (Murphy 2007; 2009). Fluctuations in sea levels have been observed in the East Kent fens continuing well into the late Holocene (Long 1992), and a Bronze Age barrow at Little Duke Farm, Deeping St Nicholas was submerged (Van de Noort 2011a).

In this way the coastline in later prehistory can be seen to have been very variable, with on the one hand land loss, but also the emergence of new land as a result of marine regressions. As with the Mesolithic period, this would have led, to some extent, to a social loss.

c. 3750 cal BC

c. 3200 cal BC

Fig. 7.1: Palaeogeographic reconstructions produced by the LOIS team. (From Shennan *et al*. 2000, 311). (Dates calibrated using OxCal 4.1).

As sea-levels rose in the Mesolithic period, higher areas were cut off and islands formed, some remaining evident across the new sea in the Neolithic period. However, as described previously (Chapter 4), sand banks, such as the Dogger Bank, are likely to be more recent developments and would not necessarily have been evident as inhabitable islands or even "visible at low tides" (*contra* Van de Noort 2011a, 144; *contra* Gaffney *et al*. 2009, 145–6; *contra* Peeters *et al*. 2009). Nevertheless, Northsealand was not "a flat and featureless plain" as Coles (2000, 398) pointed out, and islands would have existed across the new sea.

The Cross Sands Anomaly and the higher chalk ridges around the Dover Straight, for example, would have remained above the water line long after the low-lying areas had been submerged. It is unknown when these areas were finally submerged. Other land masses that resolved into larger islands included the Frisian Islands, the Channel Islands, the Isle of Wight, the Isles of Scilly, and the Molène archipelago off the coast of Brittany.

Islands may have been homes to people, but they would also have provided convenient 'stepping stones' for seafaring communities. The newly formed North Sea was therefore a vector for mobility, with crafts crossing it, moving people, animals and objects such as axes. The area, though, would still have been undergoing considerable change, for the environment was one in which the effects of storms could have lasted much longer than elsewhere. This made for choppy waters and difficult tidal conditions, in which shallow subsurface features would have created shifting eddies, making for "an unpredictable marine environment" (Garrow and Sturt 2011, 63; Callaghan and Scarre 2009).

While the western seaways are often emphasized as an important route for Neolithic seafarers (Case 1969; Callaghan and Scarre 2009; Garrow and Sturt 2011), dredged artefacts remind us that the North Sea and Channel/Manche were also travelled in the Neolithic period. These include two Michelsberg-style axes (dating to 4200–3600 al BC) dredged from around the Brown Bank area off The Netherlands coastline (Fig. 7.2). As well as two small polished axes of volcanic tuff, possibly also dating to around 4000 cal BC, recovered from around the Dogger Bank area (Fig. 7.3) (Van de Noort 2011a; D. Field pers. comm.). A further axe has also been dredged from the Solent (Murphy 2009).

Fig. 7.2: One of two Neolithic axes from the Brown Bank area (length *c*. 32cm). (From Peeters *et al*. 2009, 24).

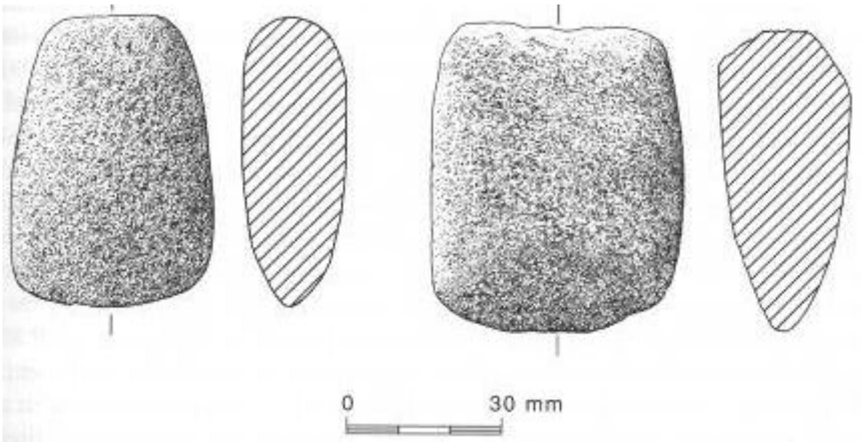


Fig. 7.3: Two possible Neolithic axes from the Dogger Bank area. (From Van de Noort 2011a, 59).

These axes, while possibly representing accidental losses – exports on their way to Britain and perhaps caught in a storm that overturned the boat – may equally represent an extension of the Mesolithic practice (discussed in Chapter 6) of formal deposition of artefacts as a response to the continued rise of sea levels. In this way, the focus may have been the land below the waters on the seabed, tentatively suggesting that a social memory of Northsealand existed in the Neolithic world.

Similar activity may have occurred in the Bronze Age. Two collections of metalwork dating to 1300–1150 cal BC have been recovered from offshore contexts around the British Isles: at Moor Sand, Salcombe in Devon, and Langdon Bay, Kent. These include weapons, tools and other bronze and gold artefacts and the former with a ploughshoe originally from Sicily (Needham and Giardino 2008). Although these finds were not associated with boat remains or any other non-perishable items that might be indicative of being part of a cargo, they are frequently interpreted as the contents of a Bronze Age shipwreck (*eg* Murphy 2009). Samson (2006) has, however, offered another way of interpreting these and other offshore

Bronze Age metalwork finds. Arguing that they fit into the broader Bronze Age depositional framework of placing metalwork in wet places (set out by Bradley 1990), she suggests that “the sea might have represented the ultimate wet place for meaningful deposition in the Bronze Age” (Samson 2006, 380).

By around 1000 cal BC the North Sea and English Channel had reached levels broadly comparable with today’s level. As seen from the maritime activities of the Roman, Anglo-Saxon and Viking people, in the following millennia the sea became of fundamental importance in the movement people, goods and for trade (Osler 2007; Murphy 2009). Increased mobility and advances in boat technology went hand in hand – mobility drove technology, which in turn created greater mobility (Van de Noort 2011a).

From around AD 1000 the growth in towns fuelled a demand for fish leading to greater use and exploration of the North Sea (Van de Noort 2011a). Throughout this period the sea developed a distinct identity, it was a “living landscape” as Van de Noort (2011a, 66) describes it. Different to land where there are trails and paths to follow; seafarers use the coastline and other features to form a ‘nautical dwelling’. The sea was also an active agent in creating social identities for those using it and inhabiting the area around it.

However, the coastal zone has always been dynamic; eroding cliffs, changing shorelines and removing land. A well-known example of this can be seen at the early medieval town of Dunwich in Suffolk, which was progressively lost due to cliff erosion. Dunwich was one of the principal medieval ports in Suffolk, and in AD 1086 had a mint, three churches, and a population of over two hundred. By the thirteenth century it had at least eight churches (Murphy 2009; Parker 1980). Following a storm in 1328, however, the harbour became choked with shingle and cliff erosion caused part of the town to collapse. Thereafter, and in the following centuries, the town was lost to the sea in sections (Murphy 2009; Parker 1980). Numerous other towns and villages have been lost in similar ways up and down the North Sea coastline, particularly along the Suffolk and Norfolk coast (Allison 1955), while in Holderness alone more than thirty places mentioned in the Domesday Book have since been lost.

Little is recorded of how people in the medieval period reacted to the destruction of their homes by the sea, but in subsequent generations losses such as these seize upon the imagination, as they are likely to have always done. Oral traditions around Dunwich claim that the sound of ringing bells can be heard coming from drowned churches beneath the sea in the advent of storms (Westwood and Simpson 2005), perhaps attesting to the way people have dealt with the loss of place, particularly sacred sites, and as way of keeping its memory alive. The sound of undersea bells is a persistent legend and known from a number of similarly lost sites, such as Aldburgh, Felixstowe, and Shipden off Cromer on the Norfolk coast (Westwood and Simpson 2005; and Murphy 2009, 179 for further sites).

Alternatively, legends involve an act of divine vengeance as in the case of Ravenser-Odd, a medieval town built on sand banks at the mouth of the Humber estuary. Ravenser-Odd was lost due to flooding, possibly a storm surge, in the fourteenth century, but according to the Meaux Chronicle:

> “chiefly by wrong-doing on the sea, by its wicked works and piracies, it provoketh the wrath of God against itself … Wherefore … the said town, by the inundations of the sea and of the Humber, was destroyed to its foundations” (Westwood and Simpson 2005, 383).

The 1607 storm surge or tsunami in the Bristol Channel was similarly seen as God’s warning (see Chapter 6 and Fig. 5.5 in Chapter 5). Others include the well-known legend of Lyonnesse (Isles of Scilly), while John Leland recorded an old legend of a lost land near St Michael’s Mount off the coast of Cornwall (Westwood and Simpson 2005). As Murphy (2009, 177) notes “the myths and legends of England incorporate what might perhaps be a folk memory of such losses”.

The sea, however, does not just take; it also gives, and although the North Sea and Channel/Manche remain active agents that still create identities, nowadays it is more often portrayed as a natural entity to be exploited. As well as fish, this includes the extraction of gas, oil and marine aggregate deposits, the latter of which are used to supply the construction industry with nearly a quarter of its cement and concrete (Wenban-Smith 2002). Just as any disturbance of the ground on land can damage archaeological sites and deposits, so too can pipe-line and cable laying or large-scale offshore developments, such as the exploitation of hydrocarbon reserves, the construction of wind farms, or the expansion of ports. Damage is also caused by beam trawler fishing, as well as continued erosion by the sea.

However, this growing economic exploitation of the North Sea and English Channel seabed has led to a greater exploration of submerged landscapes, as well as a greater need for legislation and management. In 2002 the National Heritage Act was passed in the UK, giving responsibility of the English 12 nautical miles Territorial Limit to English Heritage. This thereby gave maritime sites parity with terrestrial ones, and extended the definition of ‘ancient monuments’ to include sites under the sea (Roberts and Trow 2002; Flemming 2002; Oxley 2004).

Coincident with this was the advent of the Marine Aggregates Levy Sustainability Fund (MALSF) – a one-stage, non-deductible specific tax on the aggregates extraction industry. This allowed English Heritage to commission projects to improve knowledge of poorly understood landscapes that were at risk from aggregates extraction, including submerged landscapes, and minimize disturbance.

Furthermore, in order to tackle issues surrounding the North Sea, including the commercial trade in trawled material by fishermen, a long-term, multidisciplinary project, known as the North Sea Project, was started in The Netherlands. The commercial trade is in Pleistocene and Holocene bone and antler recovered from around the area of the Southern Bight and the Brown Bank area in particular. The project involves a number of institutions and government organisations, as well as the co-operation of fishermen. It will collate finds from the Eurogeul (the dredged shipping lane) in the Southern Bight of the North Sea, and therefore offer a history of the region (Glimerveen *et al*. 2004; Mol *et al*. 2006).

Collaboration between Rijksdienst voor het Cultureel Erfgoed, The Netherlands Natural History Museum, and English Heritage has also led to the development of a common archaeological research framework known as the North Sea Prehistory Research and Management Framework (NSPRMF). Published in 2009 (Peeters *et al*. 2009). The NSPRMF aims 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" (2009, 7).

Although the ALSF and MALSF have now run their course, the legacy of projects funded through them is immeasurable, substantially contributing to our knowledge of submerged landscapes. These projects include, amongst many others, Birmingham University's North Sea Palaeolandscapes Project (Fitch *et al*. 2005; Gaffney *et al*. 2007; 2009), Wessex Archaeology's Seabed Prehistory and Palaeo-Arun projects (Wessex Archaeology 2007; 2008a, b and c), and the four REC projects (Tappin *et al*. 2011; Limpenny *et al*. 2011; Dix and Sturt 2011; James *et al*. 2011); the information from which was used in this thesis.

Further developments have come from developer-led marine projects, particularly the push for sustainable energy and the associated construction of offshore wind farms. Archaeologists now play an integral role within this industry, and archaeological mitigation, in one form or another, is commonplace. As a result further evidence is becoming available and thus the potential for the recovery of *in situ* material increases. Although sites are often small-scale with partial data coverage, and the areas targeted are not always of prime archaeological interest, these projects have nonetheless led to substantial improvements in our understanding of the potential of preserved offshore prehistoric landscapes. There is now extensive evidence for near-shore Mesolithic palaeolandscapes around the coasts bordering the southern North Sea and Channel/Manche (Hazell 2008; Bicket 2012). Although completely submerged sites around the British Isles are still rare, with Bouldnor Cliff on the Isle of Wight as the only example. The number of offshore discoveries is also increasing, and isolated artefacts retrieved from the North Sea are now reported through the Marine Aggregate Industry Protocol for Reporting Finds of Archaeological Interest (Bicket 2012).

7.3 Reflections on Northsealand

This brings us back to the beginning of this thesis and the study of Northsealand over the last century. The archaeological study of sea-level rise can be traced from early recognitions of submerged landscapes in the nineteenth and early twentieth century through to mid- and late twentieth century landscape reconstructions and sea-level curves. And from there to the more recent seismic surveys that have revealed selected parts of the topography of Northsealand. There is also now a sophisticated understanding of the complicated processes that submerged this landscape in the early Holocene, including eustatic sea-level rise, isostatic readjustment, the forebulge effect, and hydro-isostasy (set out in Chapter 3).

As can be seen from the above, there is good and ever-growing evidence for Northsealand from archaeological sites in and around the North

Sea and the Channel/Manche. This thesis has for the first time brought this very disparate information together, showing that enough exists to be able to provide a basic characterisation of the different parts of the landscape (Chapter 4). In general terms, Northsealand comprised low-lying and fluvially dominated wetlands with reed swamp and carr woodland, but distinct areas and landforms are discernible. The Outer Silver Pit, for example, dominated the topography of the northern part of the area; originally a vast lake fed by nearby rivers, it must surely have been a major aggregation point for animals and Mesolithic communities. Later with sea-level rise it became a marine outlet, although is likely to have retained its importance as a central node. The Dover gorge to the south of the southern North Sea, the area of the Dover Strait now, although unrecognised in the literature, must too have been of prime importance to early Mesolithic communities. The South Downs extended across this area, as did the Weald, the latter in particular well known in Mesolithic studies as being of prime importance to communities at this time.

These terrestrial sites give the now drowned area context, but the recognition is reciprocal, for it should now also provide these terrestrial sites with context. The Cross Sands Anomaly also stands out, metaphorically and literally, as a landform that is likely to have attracted, in one way or another, Mesolithic people, and must repay further analysis. The Rhine/ Meuse/ Thames deltaic plain and the banks of the braided Channel River would undoubtedly have also been a major focus of activity in the Mesolithic period.

The three main river systems that drain across Northsealand – two draining to the north, and one to the south, may well represent the major social networks in the early Holocene; perhaps, as noted in Chapter 4, with the Channel River to the south of the Dover gorge representing a fourth separate social area. Incorporating these sorts of social considerations should be a priority when characterising Northsealand, and this thesis represents one such attempt.

It can clearly be seen from the data presented here that coverage is patchy and further work should include expanding the seismic surveys to include other areas; this is particularly so on the Continental side where there is currently a lot less information. Focussing on areas of potential interest, such as the area around the Dover gorge, may also be productive. Further, it is crucial that the information from terrestrial sites is now linked with the emerging datasets from the North Sea and Channel/Manche. A point made recently:

> "to produce a fully source-to-sea approach to prehistoric archaeology, completely integrated with palaeogeography, where modern coastlines are no boundary to methods, theories and concepts should be a major priority for the next generation of research" (Bicket 2012, iii).

As discussed in Chapter 4, the landscapes detailed by the various surveys are palimpsests. In order to understand how these landscapes evolved and to be able to reconstruct them fully there needs to be a robust chronological framework to work from. Even basic information, like the date of the breaching of the Outer Silver Pit, for example, is currently missing, making a study of the human perception of change difficult.

The amount, timing and variation of these events are also little known. As Chapter 3 sets out, the large-scale averaged models used to describe sea-level rise, while not necessarily meaning to, have led to a view that the inundation was a slow, continuous process. Along with the large scale of many of the recent survey projects, this has limited discussions of the human experience of change by not emphasising quick, abrupt and perceptible perturbations. By focussing on short-term, local-scale dynamic changes, however, a study of the human perception and experience of change becomes a realistic possibility. This may be achieved through coring work to target specific landscape features evident in the surveys. This might allow greater accuracy in modelling, for example, palaeotides. As well as help define the environmental record, which at the moment is also poorly understood.

In this way a closer collaboration between landscape archaeology and environmental archaeology as envisioned by Chapman and Gearey (2000) becomes a realistic possibility. Northsealand researchers need to "adopt a complementary approach that acknowledges variability and seeks to explain it" (Passmore and Waddington 2012, 121).

Although sea-level rise and climate change occurred globally and on a millennial-scale, it unfolded and was experienced at a local and generational level (as set out in Chapter 3). The local-scale provides us with a better understanding of the effects of sea-level rise, a sense of the experience of it, rather than simply recording it as an abstract concept. Further, the local-scale can identify problems that are not necessarily obvious from the larger scale; it provides a more complex understanding of environmental change. As Bailey states: "more detailed testing … will, of course, depend on more detailed local studies" (2007, 8; 2004).

Detail of the character and dating of the landscape and a local-scale understanding of sea-level rise, will lead to more accurate descriptions of the effects of sea-level rise and how these may have been perceived. As the wide-ranging and multi-disciplinary study in Chapter 5 detailed, these effects would have included, at different rates and at different times: submergence and loss of land, erosion of the coastline, increased flooding and storm damage, saltwater intrusion into aquifers, changes to estuary morphology and tidal regimes, the loss of resources, and reduced territory.

Chapter 6 was another multi-disciplinary study that examined some possible responses to these changes. These may have included flexibility, diversification, wide-scale movement, and an intensification of ritual practices. Chapter 6 also highlighted the role of knowledge and information in increasing resilience, suggesting that by actively engaging with their surroundings and monitoring the environment, Mesolithic people could build an accumulated knowledge of their changing environment that then increased their resilience to the changes taking place.

Key to fully appreciating the effects of and responses to sea-level rise is the re-evaluated understanding of Mesolithic human-environment relations and the way they related to their surroundings (laid out in Chapter 2). As Spikins suggests "… a potential 'way forward' for interpretations of Mesolithic societies lies in the development of more dynamic ecological and ethnographic models" (1999, 128). As emphasised in this thesis, it is unlikely that Mesolithic communities perceived sea-level rise as a separate entity, an external force against which they struggled to control, but that it was an integral part of their changing world. In this way, the person and the environment were not separate, but parts of a single process.

A key recognition in this thesis has been that the way people perceive their environment is essential to understanding their possible responses to it. As Sprout and Sprout put it in 1965: "moods, attitudes, values, preferences, choices, decisions, projects and undertakings are relatable to the milieu through the perceptions and other psychological processes of the environed individual" (1965, 140). Change is an intrinsic aspect of any environment, and Mesolithic communities would have had a fundamental awareness through a sensorial engagement of these changes, and acted accordingly.

That is not to say that sea-level had no effect on people, for as Chapter 5 makes clear, if one's environment changes, so too does the experience and sense of self too. Furthermore, a sense of place develops through an active, embodied engagement with the physical world: through the knowledge, the familiarity, and the experience of it, and that human identity is intrinsically linked to it (Chapter 2). It follows, therefore, that by losing it, part of the self is lost. The loss of land in the Mesolithic period – the loss of places, familiar locales where myths were created and identities formed – would have profoundly affected people's sense of being (Chapter 5). So while it is inescapable that those displaced by the rising sea were fundamentally changed by it, there is still a need to interpret the social implications of environmental change. People were not just 'coping', but getting on with life – with all its trials and hardships, satisfactions and pleasures, and with a multitude of choices available.

A point not discussed in this study, but one that merits further work and so briefly outlined here, is that sea-level rise did not occur in isolation but alongside other environmental changes. These would have created other and different challenges and opportunities. Climatic conditions during this period are likely to have been highly variable (see, for example, Anderson 1998; Anderson *et al*. 1998; Macklin *et al*. 2000; Magny 2004; Mayewski *et al*. 2004) with increased chances of changeable and unstable weather patterns. Changes to the temperature and the environment would mean that some birds arrived and migrated at different times. For example, warmer temperatures would have led to wintering geese arriving later and leaving earlier, meaning fewer eggs were laid and reducing opportunities to hunt them.

An analogy can be found in modern climate change in Britain, which is affecting the distribution and abundance of species, changing the timing of their reproductive events, and shifting distributions northwards and to higher elevations (Hickling 2006). The range margins of species such as butterflies and Odonata, such as dragonflies and damselflies, are argued to be shifting at a rate of 12.5–24.8 km per decade (Hickling 2006, 136). While this is proving beneficial for many southern species, it is severely affecting populations at the southern and low-elevation limit of their species' distribution in Britain, pushing them towards local extinction (Hickling 2006). Further, while year-on-year temperature rise is clearly affecting species, it is the increased extremes in weather that is having the greatest effect on British populations (Hickling 2006).

This would have been as true of the past as it is of today, and sudden environmental changes, such as the drop in temperature as a result of the '8.2 kya cold event' (Barber *et al*. 1997; Chapter 3), are likely also to affect the health and body condition of animals. This would have led to, for example, the death of bird chicks and deer calves. Unusually hot weather would have caused larger animals to overheat, become exhausted and thin, leading to lower population levels. In Nain, Labrador, modern temperature rises are thought to be responsible for a greater number of sick and diseased animals, particularly parasites in the liver of caribou that affect the taste and texture of the meat (Furgal *et al*. 2002). Minc and Smith (1989) note that reduced physical condition of caribou as a result of overgrazing of summer pasture increases vulnerability to parasites and disease. Further, poor nutrition can delay the age of sexual maturity in females making it hard for the herd to recover.

Warmer weather in the Arctic has also increased the number of mosquitoes. These not only harass the caribou, influencing their health and distribution, but are also a nuisance to people, making travelling, hunting, and camping more difficult (Thorpe *et al*. 2002, 214). It is reported that rising temperatures in the Canadian Arctic are affecting the caribou in ways that could not be identified in the archaeological record, for example the meat now tastes different to the Inuit, and the skins are of poor quality (Fox 2002). This is probably the result of poor vegetation growth on which caribou feed, or changing vegetation, which then affect the health of the animals.

Periods of aridity would have affected some foods, such as berries, since a greater solar intensity would make berries smaller or shrivel, thereby reducing their value (both raspberry and blackberry were attested at the Mesolithic site of Goldcliff in the Severn Estuary [Bell 2007]). Heavier rains (suggested by a shift to wetter conditions toward the end of the Mesolithic: Anderson 1998; Tipping 1994; Tipping and Tisdall 2004; Tipping *et al*. 2008) could have affected, for example, bee populations and thus the pollination of fruiting species. Changes in precipitation, particularly its frequency and timing, also affects soil conditions and river discharge and consequently impacts on the biodiversity of fish populations and certain macroinvertebrates (Sievers 2012).

Changes in the temperature would also alter river and lake levels (Digerfeldt 1988; Sarmaja-Korjonen 2001; Macklin and Lewin 2003; Magny 2004), which in turn affect the size of the fish. Warmer water temperatures may well increase the presence of parasites and the likelihood of infection by pathogens in fish (Sievers 2012). Fish metabolism is directly linked to water temperature, with direct consequences on food consumption, growth and foraging behaviour (Sievers 2012). And whilst higher temperatures can be beneficial for spawning, they can have fatal consequences on egg development (Sievers 2012). Furthermore, water levels affect fish migrations upstream and into inland lakes, impacting the location and timing of harvesting and therefore the local diet. Changes such as these, alongside changes associated with sea-level rise, could have had a profound influence on peoples' diets and resulted in considerable adjustments to their usual activities, to say nothing of the previously mentioned effect on ontological understanding.

The above represents just a few selected examples of the ways climate change can have a profound impact on peoples' lives. Yet many of these could never be predicted from large-scale models. Who could guess, for example, that warmer weather could affect the taste and texture of caribou meat? Or that it would result in an increase in mosquitoes which then becomes such a nuisance that people even change their hunting habits, and caribou their distribution? This emphasises the challenges faced studying past perceptions of environments, and changes to them. Nevertheless, there is a need to better comprehend the array of human responses to environmental change and sea-level rise, and to this end work should continue to compile ethnographic examples of responses as well as motivations for the response. It is also essential to understand environmental change as an inherent part of the world, rather than an aberration.

Perceptions of, and responses to, past sea-level rise are only rarely considered in archaeological discourses despite the fact that people lie at the heart of archaeology. This thesis has sought to rectify this situation. It has also explicitly laid out that to fully understand the effects of sea-level rise, a non-dualistic view of the body and the environment as one process is needed. This study has focused on the perceptions of landscape change during the Mesolithic period by discussing how people and communities were affected by, and reacted to, sea-level rise. It has moved beyond the static approach normally applied to Mesolithic environmental change and captured some of the nuances that are frequently missing from the archaeological literature. It has also highlighting the close and intense relationship between humans and their environment.

Through this, it is hoped that a fresh approach to Mesolithic environment relations and a richer and more complex story of early Holocene sea-level rise can be developed. Given the highly dynamic landscape and the potential for well-preserved remains, for the archaeologist, Northsealand is an excellent venue for understanding the ways humans have interacted with and within their environment.

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The two brothers huddled together, their bodies pulled tight into cloaks sodden with rain and spray from the sea. The boat growled with every wave; rhythmically rocking the men as it mounted each rolling upswell, cresting in time for the next. As far as the eye could observe was sea, and it had been so long since leaving the last island that the sun, glimpsed only occasionally through dark mackerel clouds, had spanned the sky. This landscape is barren to the terrestrials, to the farmers that know not of the wetlands and the mighty gorge below, but to these men it is replete with meaning. They spent their lives at sea – their mother used to say they had been born in a boat – and for them the rich texture of the watery surface is as readable as the land, full of named locales reflecting its form and character. They know where to find the shoals of fish, the oyster beds and seal pups. They know the dangerous places never to cross, and they know of the ground beneath, the rises and falls that were once rolling hills and river valleys, and where, at low tide in shallows around islands, to see dead trees protruding from the water like the grisly teeth of a wretched monster. And they know, through stories told and retold to them by their parents, that this was the drowned land of their ancestors.

Ahead they could see something – a subtle change in the timing and direction of the undulations; white caps now just visible on the wave peaks reflecting a slight rise in the seabed below. They had arrived. They had told stories of their childhood all journey, but barely a word had been uttered since leaving the last island, and now the silence seemed to deepen. Bending, a brother pulled out a large object from under his seat and laid it on his lap; the cloth wrapping falling open at one end revealing the glossy red surface of two polished axes lying one on top of the other. The other watched quietly, fingering a leathery pouch beneath his cloak – the burnt bones unmistakable within. The movement of the boat changed as they entered their destination, and simultaneously they slid across to one side pausing briefly to look at each other before tenderly holding out their arms and allowing the offerings to drop through the water to the land below. Their mother had finally returned to her ancestral homeland. Like droplets of water emerging from a spring and setting on a journey across land, it all ends with the sea.

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Later, two brothers work at the side of a boat; one operating the winch while the other guides the net up as it emerges with a roar from the water. The net swings across and with a yank from the younger of the two, its fishy contents spill onto the deck. “There are bones in this one” he says, “what shall I do?” “Throw them back in” replies his brother walking away, before pausing and turning, “keep the mammoth tooth though – we can sell it on e-bay.”

Meanwhile, in a different part of the world, a man stands in the shallow sea, his trousers rolled up to his knees. A camera, set on the beach, watches him as he talks about his family and his land. And he tells the world that this land, under the water, was once his family’s home.

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