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The Great Fossil Mine of the southern North Sea: exploring the potential of submerged Palaeolithic archaeology

by

Rachel Bynoe

Thesis for the degree of Doctor of Philosophy

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ABSTRACT

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THE GREAT FOSSIL MINE OF THE SOUTHERN NORTH SEA: EXPLORING THE POTENTIAL OF SUBMERGED PALAEOLITHIC ARCHAEOLOGY

Rachel Bynoe

This research explores the potential of the submerged Palaeolithic archaeology of the southern North Sea for answering questions about how hominins occupied and adapted within their environments in these northerly latitudes throughout the Pleistocene. Recent coastal discoveries in East Anglia have demonstrated occupation as far back as ~1 million years, and yet our appreciation of the how, why and who of this occupation is missing a crucial piece of its puzzle; excluding these now-submerged landscapes is an active bias on our understanding, truncating the archaeological record.

Having been subjected to repeated glaciations, trans- and regressions, the very processes that led to the terrestrial exposure of these areas have subsequently led to their neglect: the assumption that pre-LGM deposits will have been eroded or re-worked has prevailed. Recent work, however, has demonstrated the inaccuracy of this assumption, with evidence for extant Pleistocene-age deposits, landscape features and archaeology. Unlocking the clear potential of these submerged landscapes now relies on the approaches that we take to their investigation as, to-date, all archaeological finds have been entirely by chance. In order to move beyond this reactive style of archaeology, methodologies must be developed which tackle these areas in a more focused and reasoned way.

The research undertaken throughout this PhD makes steps towards this. Starting from no baseline understanding of the nature of the existing resource, this work located, collated and analysed a prolific collection of 1,019 faunal specimens. Recovered by the 19th and 20th Century UK trawling industry, the development of historical methods has elucidated their locations and conditions of collection. Combining this locational information with species taxonomic evolution, the emergent spatio-temporal patterns provide a fresh understanding of the integrity of the extant deposits and unique opportunities for locating them on the seabed. These results are presented at a range of scales:

- First, a broad-scale understanding of offshore regions across the southern North Sea which have demonstrated a dominance of cold-stage species from MIS 8-MIS 2.
- Secondly, a local scale: linking faunal remains with seabed features in the near shore area off Happisburgh, identifying Early and early Middle Pleistocene assemblages related to exposures of the CFbF.
- Finally, a discrete, high resolution area of seabed off the coast of Clacton has been identified. Through the collection of swath bathymetry, this area has shown the exciting correlation of Pleistocene seabed deposits and faunal remains.

This research presents a significant move towards a proactive approach to these submerged landscapes and represents a step-change in our ability to understand, locate and engage with this undervalued archaeological resource.

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Academic Thesis: Declaration Of Authorship

I, Rachel Bynoe

declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

The Great Fossil Mine of the southern North Sea: exploring the potential of submerged Palaeolithic archaeology

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;

2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;

3. Where I have consulted the published work of others, this is always clearly attributed;

4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;

5. I have acknowledged all main sources of help;

6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;

7. Either none of this work has been published before submission, or parts of this work have been published as: [please list references below]:

Signed: ………..

Date: ………..

Acknowledgements

The work undertaken throughout this PhD has only been possible through the help and support of a range of people who I would like to thank here. First, of course, I need to say thank you to my family for their constant understanding and, specifically, to my dad for his extensive proof-reading of this thesis at such short notice. Also to Dan, for supporting me in so many ways over the past three years.

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Chapter 1: Introduction

1.1 Introduction

Over recent years internationally significant research from the coastal sites of Happisburgh and Pakefield in East Anglia has transformed our understanding of the antiquity of hominin presence in Britain, with major implications for movement and dispersals on a global scale (Parfitt *et al.* 2005, 2010). These discoveries have reframed the questions we are asking about the Palaeolithic occupation of North West Europe and highlighted the importance of looking to the submerged archaeological record of the southern North Sea, an unexplored landscape demonstrably used by these hominins. We now know that the deposits of the southern North Sea represent multiple layers of landscapes laid down throughout the Pleistocene epoch (Long *et al.* 1988; Cameron *et al.* 1992; Gibbard 1995; Rose 1999; 2001; Hijma *et al.* 2012), with those being archaeologically relevant spanning the Palaeolithic ~1Ma-0.01Ma (latest Early – Late Pleistocene). Climatic fluctuations throughout the Pleistocene dramatically altered these landscapes; ecologically they may represent areas for which we have no modern analogue, the faunal and floral communities that we recognise as 'native' would appear unfamiliar and the shorelines delineating the landmasses have undergone significant fluctuations, sometimes on human timescales. The sea level changes, climate and geology of these landscapes are increasingly understood from both a terrestrial as well as offshore perspective; by contrast, the Palaeolithic archaeological record remains unknown.

From an archaeological point of view, trawled bone remains which have been stored in museums' collections since the 19th Century tell us that these were important landscapes for diverse species of fauna (eg. Van Kolfschoten and Laban 1995; Mol *et al.* 2006; Reumer *et al.* 2003) and a recovered Neanderthal (Dutch waters, Text Box 1 [Hublin *et al.* 2009]), as well as a dredged assemblage of handaxes (UK sector; Text Box 1 [Russell and Tizzard 2011]), tells us that it was similarly important for our hominin ancestors. Despite these finds there are still huge gaps in our knowledge, specifically from a Palaeolithic archaeological perspective, and the appreciation of this record, which potentially represents repeated episodes of terrestrial occupation, is often reduced to a homogenous mass or simply a means by which hominins moved from A to B. With the drowning of these areas leading to the invisibility of large portions of Palaeolithic landscape, there are significant repercussions for our understanding of the physical record and its social and behavioural implications.

Frameworks to investigate and work towards management strategies for this archaeology have been set up between European countries bordering the North Sea (Peeters *et al.* 2009), which is a step forward in acknowledging the potential of these areas, as well as the risk they face (see also the Marine Management Research Framework 2012). Recent practical advances in Palaeolithic research in the offshore zone has mirrored the terrestrial situation in that it has been largely development-led, with much funding and work coming out of commercial projects. Terrestrially, gravel extraction and commercial development (such as the CTRL [Wenban-Smith *et al.* 2006]) has led to the investigation and drive to understand these deposits and their archaeology (Hosfield 1999; Wenban-Smith and Hosfield 2001; Hosfield and Chambers 2004; Ashton and Hosfield 2010). Offshore, the increase in activities such as dredging and wind farms has led to developer funding (such as the Aggregate Levy Sustainability Fund) into the exploitation of these areas, which has revealed both Palaeolithic features as well as associated extant deposits (Wessex Archaeology 2008; Russell and Tizzard 2011; Dix and Sturt 2011). What is even more astounding, however, is the discovery of Area 240, an *in situ* Palaeolithic site 30m below sea level off the coast of Great Yarmouth (Text Box 1; Russell and Tizzard 2011). It is increasingly clear that, despite years of neglect, there is a strong case for research into the submerged Palaeolithic of the North Sea.

A similar situation as regards interest and research is also developing on the other side of the southern North Sea, in Holland. Dutch archaeologists have been working on the use of faunal remains dredged from the Eurogeul (the deep water shipping lane of the Port of Rotterdam) to look at the development of palaeoenvironments and hominin use of the area during the Late Pleistocene (Mol *et al.* 2006) and have also discovered part of a Neanderthal skull from the Zeeland Ridges (Text Box 1; Hublin *et al.* 2009) as well as, more recently, modern human remains (Parfitt pers. comm.). This record is demonstrably both extant and significant, with fossil material being preserved alongside palaeoenvironmental proxies (Mol *et al.* 2006) demonstrating, for example, the prevalence of *Coelodonta antiquitatis* (woolly rhinoceros) in the southern North Sea relative to any other location in the Late Pleistocene (Section 4.6.2). This pattern appears to indicate the potential for non-analogue fauna existing in environments for which we currently have no evidence. It is these types of information that will help build up a picture of the varied ecologies that existed in this area throughout the Palaeolithic and the dynamic landscapes of contemporary hominins.

1.2 History of the study

The existence of both pre- and post-Weichselian landscapes has been recognised since the mid-late 19th Century (eg. Davies 1878; Reid 1882; 1890; 1913), with fossils of long-extinct megafauna recovered from the seabed since the early days of trawling. The presence of peats and submerged forests along the coastlines also piqued curiosity, with Clement Reid and the British Geological Survey even going to far as to search for Pleistocene (then 'Pliocene') deposits on the seabed off Happisburgh (Reid 1890, 173), and publishing on species distributions from the Dogger Bank (eg. Davies 1878; Reid 1913). *Submerged Forests*, published by Clement Reid in 1913, discusses these drowned landscapes around the coast of Britain. Although concentrating on the post-glacial (i.e. post-Last Glacial Maximum) deposits, Reid does note that the older, Early to early Middle Pleistocene deposits of the East Anglian Cromer Forest-bed Formation (CFbF, Text Box 3) are extant (albeit in a rather disregarding manner: "*this need not now detain us*" [Reid 1913, 39]). What is striking about this work is that Reid is adamant that the systematic examination of these deposits for geology, archaeology or natural history is extremely important in answering questions about sea level, climate, hominin species and how they lived, migrated and interacted with their environments. He is also very perceptive, stating that *"…the archaeologist is inclined to say that they 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, 2). Although

Quaternary geologists would not these days consider these deposits insignificant, or too recent, it is certainly true that the potential Palaeolithic archaeology they contain has often been overlooked. Thus, although Reid's focus was not primarily archaeological, he is acutely aware of the implications of these submerged deposits and is advocating a multidisciplinary approach; it all sounds very familiar and it is remarkable to see it being promoted a hundred years ago. Even more remarkable is the lack of interest since.

After the work of people such as Reid and Clark during the late 19th Century and early 20th Century, the issue was all but dropped. Thankfully, the 'speculative survey' of Bryony Coles (1998) saw a return to an acceptance of the North Sea as a viable area of archaeological research, and the coining of the term 'Doggerland'. Although it was purely theoretical and aimed at the post-Weichselian potential, the broader importance of this research lies in the way that it challenged attitudes towards these submerged landscapes. Coles redefined these now-submerged areas as habitable land, in contrast to their previous image as a kind of highway between Britain and the continent. She stressed the importance of viewing them as they would have been experienced by the contemporary hominins and the images she used to illustrate her work stress this (Figure 1.1).

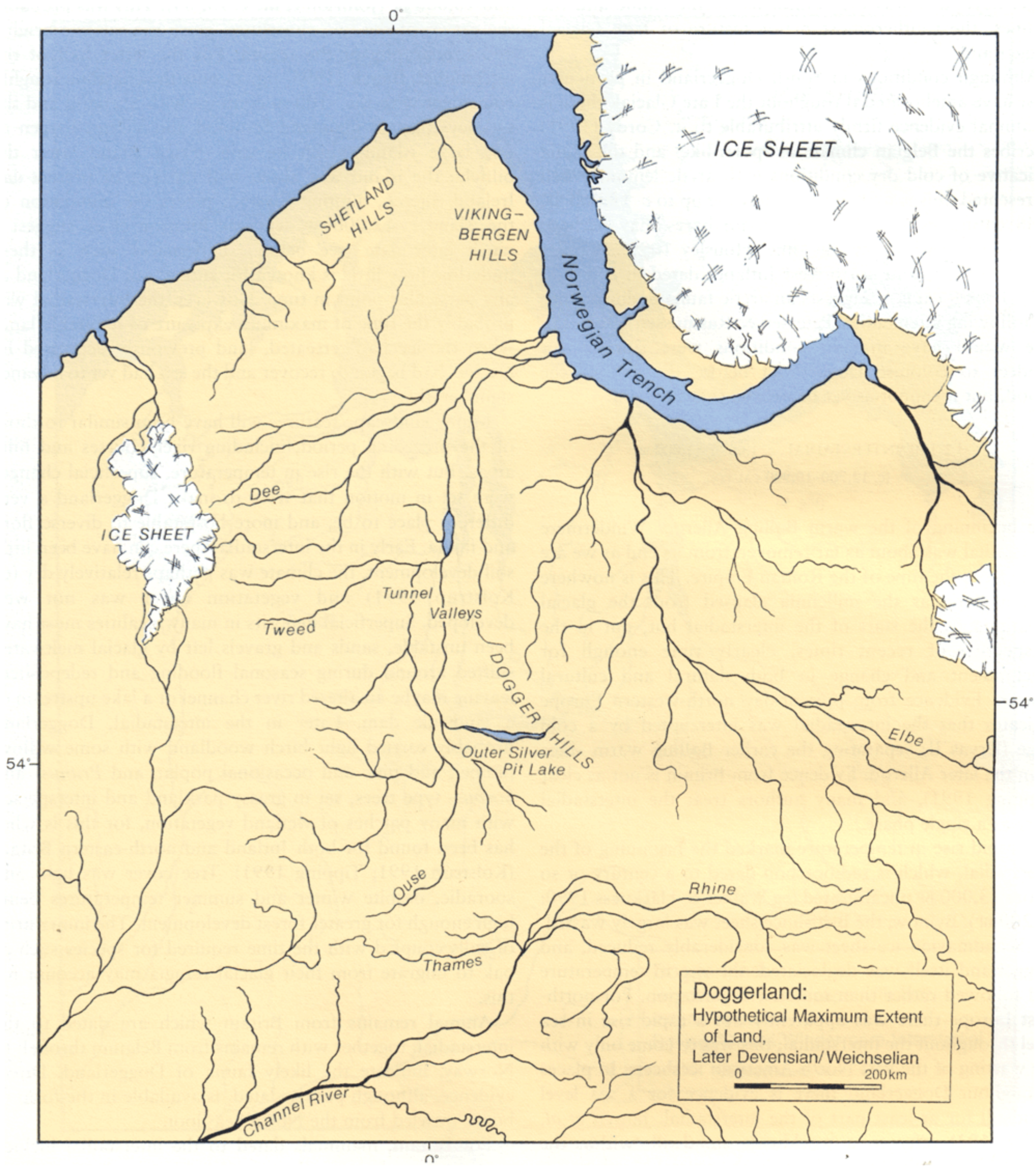

Figure 1.1 Bryony Coles' image which discarded modern land-sea boundaries in favour of promoting a more inclusive picture of Palaeolithic/Mesolithic landscapes (Coles 1998).

Over the past few decades, research that has been conducted in the UK sector has been pre-dominantly focused on the post-Last Glacial Maximum (LGM) archaeology of the region, most likely because of its increased chances of survival (e.g. Coles 1998; Fischer 1993; 2007; Gaffney *et al.* 2007; 2009; Fitch *et al.* 2011; van Kolfschoten and Laban 1995; cf. ongoing work by AHOB). Nevertheless, recent work has demonstrated the potential for preservation of Palaeolithic archaeology in the southern North Sea (e.g. Wessex Archaeology 2008; Russell and Tizzard 2011; Dix and Sturt 2011), an idea that has been gaining support over recent years (e.g. Peeters *et al.* 2009; Marine Management Research Framework 2012). However, this work is still very much focused on geophysical imaging and Quaternary deposit models, rather than the physical archaeological remains.

In terms of the Palaeolithic before the LGM, engagement with these areas has been largely limited to speculative statements accepting that they were terrestrial and exploring how that might have affected the record (eg. Ashton and Lewis 2002; White 2006; Ashton *et al.* 2011). Other work has focused on the potential of these areas to provide information on Palaeolithic coastal exploitation and migrations (Westley and Dix 2006; Bailey and Fleming 2008) as well as the survival of deposits and archaeology (Wenban-smith 2002; Dix *et al.* 2004; Hosfield 2007; Ward and Larcombe 2008). So despite current research providing us with very good reasons for, and approaches to, the submerged record, methodologies - at least for the UK - are still largely speculative and based on questions of potential. As a result we do not understand the extent or nature of the artefactual Palaeolithic record from these submerged landscapes; there has been no overarching assessment of the material the southern North Sea has yielded. We therefore have no foundation of knowledge from which we can begin to work and so we cannot begin to investigate the timing of hominin occupation, or, as importantly, the timing and reasons for abandonment.

Appreciating this record is clearly a priority and we must strive towards a situation where the onshore and offshore records are understood seamlessly, not as separate entities. Moreover, a move away from a finds-driven, serendipitous approach (highlighted by projects such as Area 240 (Text Box 1) and towards a bottom-up, focused approach informed by an understanding of geological and archaeological signatures, must be aimed for if we are to successfully move research in this area forward. Integration of data from submerged regions will allow us to piece together these wider environments and fully understand the hominins within them.

This research therefore proposes to redress the balance by carrying out the first quantitative analysis of the existing resource from the UK offshore sector. The specimens collated are primarily faunal, with 1,019 individual elements, although coastal lithics are also examined. This research adopts a multi-scalar approach, with higher resolution, local investigations (Chapter Five and Section 4.2.1, 4.6.3) presented alongside broader, regional analyses (Section 4.2.2, 4.2.3). Linking this long-forgotten faunal material, spanning the Early to Late Pleistocene, with available geophysical and geotechnical data will provide the framework for us to begin actively engaging with these unexplored landscapes, bringing context to the contemporary hominins within them.

1.3 Geographical focus

Geographically, the focus of this research is broadly defined by a flexible interpretation of the modern boundaries of the southern North Sea basin. This interpretation essentially respects this boundary, which reflects the shallowest area of the North Sea and is bordered by the Dogger Bank and German Bight at its northernmost extent and the Southern Bight in the south (Figure 1.2).

This study area has been defined by several factors:

- The cyclical exposure of the southern North Sea basin as dry, habitable land throughout the period of Palaeolithic occupation, making this area archaeologically relevant.
- The avoidance, at its southerly extent, of major glacial advances (Figure 1.2) as well as its net subsidence throughout the Pleistocene period, acting as a 'depocentre' for major European rivers (Figure 1.3, Figure 2.2).
- Centuries of trawled fossil remains of Pleistocene dating from the southern North Sea as well as lithic and faunal material recovered from beaches, demonstrating the existence of these landscapes and the preservation, albeit fragmentary, of associated deposits.
- The historical locations of fishing activities (via British trawlers) in the approximate vicinity of the southern North Sea.
- The discovery of exceptionally early sites, Happisburgh 3 and Pakefield, on the coast of East Anglia and western shore of the southern North Sea, demonstrating the earliest occupation so far known from North West Europe (c. 814-914kya and 700kya respectively [Parfitt *et al.* 2005; 2010])

in a unique preservational environment (eg. Cohen *et al.* 2012; Section 2.1.1).

Although using the entire southern North Sea as a broad study area, the trawler-derived specimens that this research concentrates on are from the UK fishing industry alone. In this respect, when this work refers to the UK sector, it is referring to the UK based industries exploiting the southern North Sea.

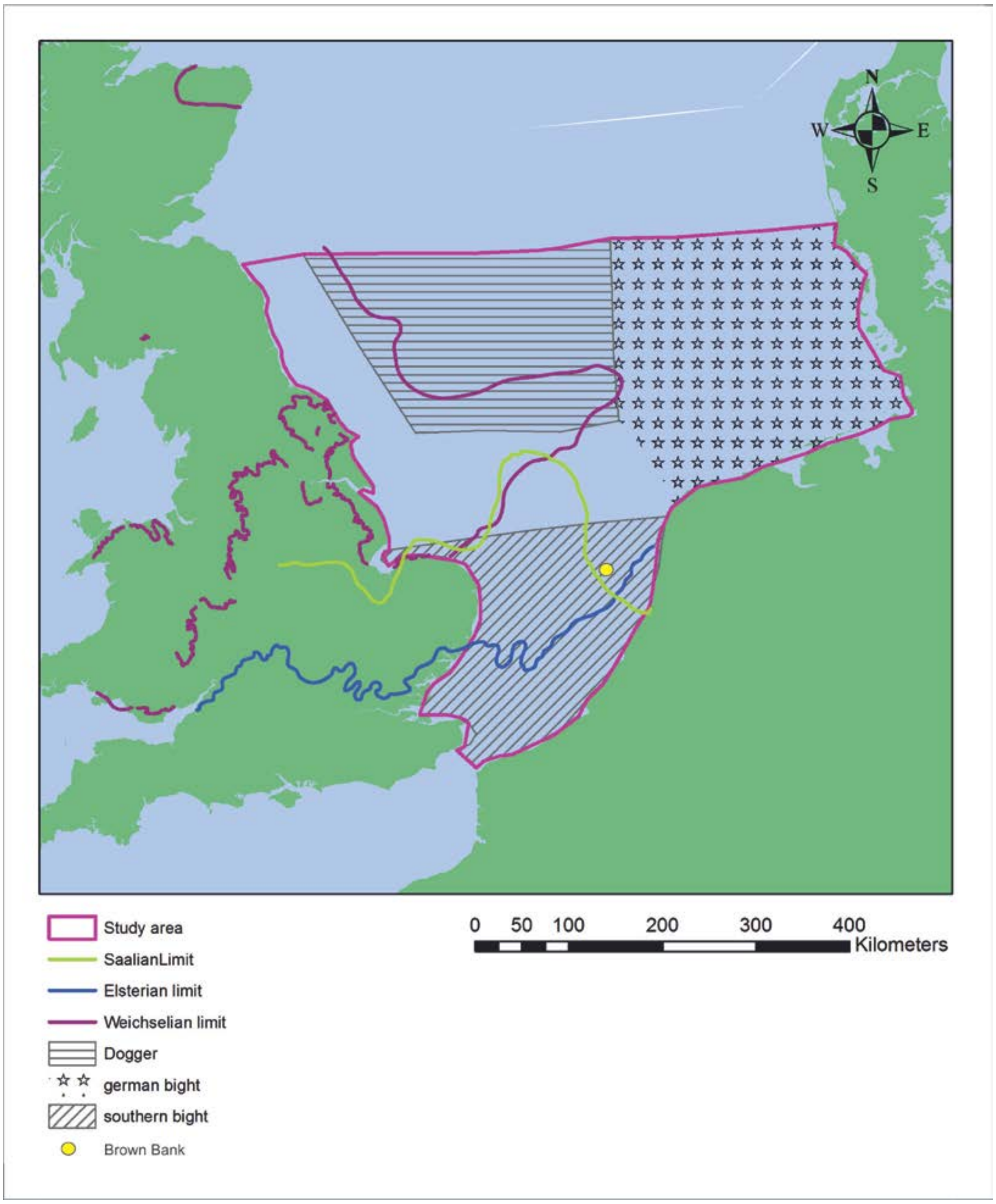

Figure 1.2 Broad area of study showing positions of the German and Southern Bights as well as the Dogger Bank. Mapped glacial extents are also shown (Graham *et al.* 2011; Lee *et al.* 2012).

The geological history of the southern North Sea basin has facilitated the survival of Pleistocene deposits and the artefacts they contain, making it a key area for this research (Ward and Larcombe 2008). In addition, the development of the trawling industry in this area throughout the 19th Century provided the means by which the faunal specimens that relate to these submerged deposits were recovered, with the emergence of the aggregate industry in the later 20th Century further adding to this resource.

The North Sea is within an area of tectonic subsidence that has been active since the Oligocene (Cloetingh *et al.* 2006), with the hinge zone running approximately along the East Anglian coastline (Figure 1.3; Hijma *et al.* 2012). These conditions have facilitated rapid burial and preservation of deposits over relatively short timescales (Long *et al.* 1988; Cameron *et al.* 1992; Rose 1999; 2001; Cohen *et al.* 2012). A shallow marine embayment characterised the northerly section of the southern North Sea of the Early – early Middle Pleistocene period (Figure 1.3, Figure 2.1), fed by a series of large European and British rivers (Thames-Meuse-Rhine, Bytham) that which deposited their bedloads into the basin. A constant terrestrial connection existed to the south – in large part due to the existence of the Weald-Artois anticline (Figure 1.3). Britain was essentially a peninsula of Europe; a constant exchange of fauna and flora was possible, as indicated by the finds of Pakefield and Happisburgh 3 (Parfitt *et al.* 2005; 2010).

During the Elsterian glaciation major landscape reorganisation occurred (throughout this thesis the Elsterian glaciation is taken as being synonymous with the Anglian glaciation and Marine Isotope Stage 12 [Toucanne et al. 2009a; Graham et al. 2011; Bose et al. 2012]): the breaching of a pro-glacial lake which built-up in the southern North Sea, bounded in the south by the Weald-Artois anticline, eventually led to the catastrophic breaching of this chalk ridge (Gupta 2007) and initiated the change to the cyclical pattern of terrestrial land/sea that characterised this area until the Holocene transgression (although not immediately, with a connection still apparent in MIS 11, 9 and early 7. Section 2.1.1, Section 2.3.2.1, Section 2.3.3.1). Submerged terrestrial deposits dating to these later periods are therefore varied in their extent and location, but increasingly restricted to periods of lower sea level (and colder climate), or to areas of increased sedimentation that were then terrestrial at times of high sea level. Of course erosion and deformation has still occurred through fluvial, tidal and glacial forces, dissecting and fragmenting the record (eg. discussions between Lee *et al.* 2004, 2006 and Preece and Parfitt 2008; Preece *et al.* 2009, Section 2.2), making interpretation problematic but by no means impossible. However, the southern

North Sea has managed to avoid the extremely erosive powers that have affected the Channel to the south, and (much of) the direct glacial erosion of the northern North Sea (Cohen *et al.* 2012). So, the relatively good preservation of deposits, a long history of artefact collection and remarkable contemporary terrestrial archaeology combine to provide a strong case for the southern North Sea as a study area.

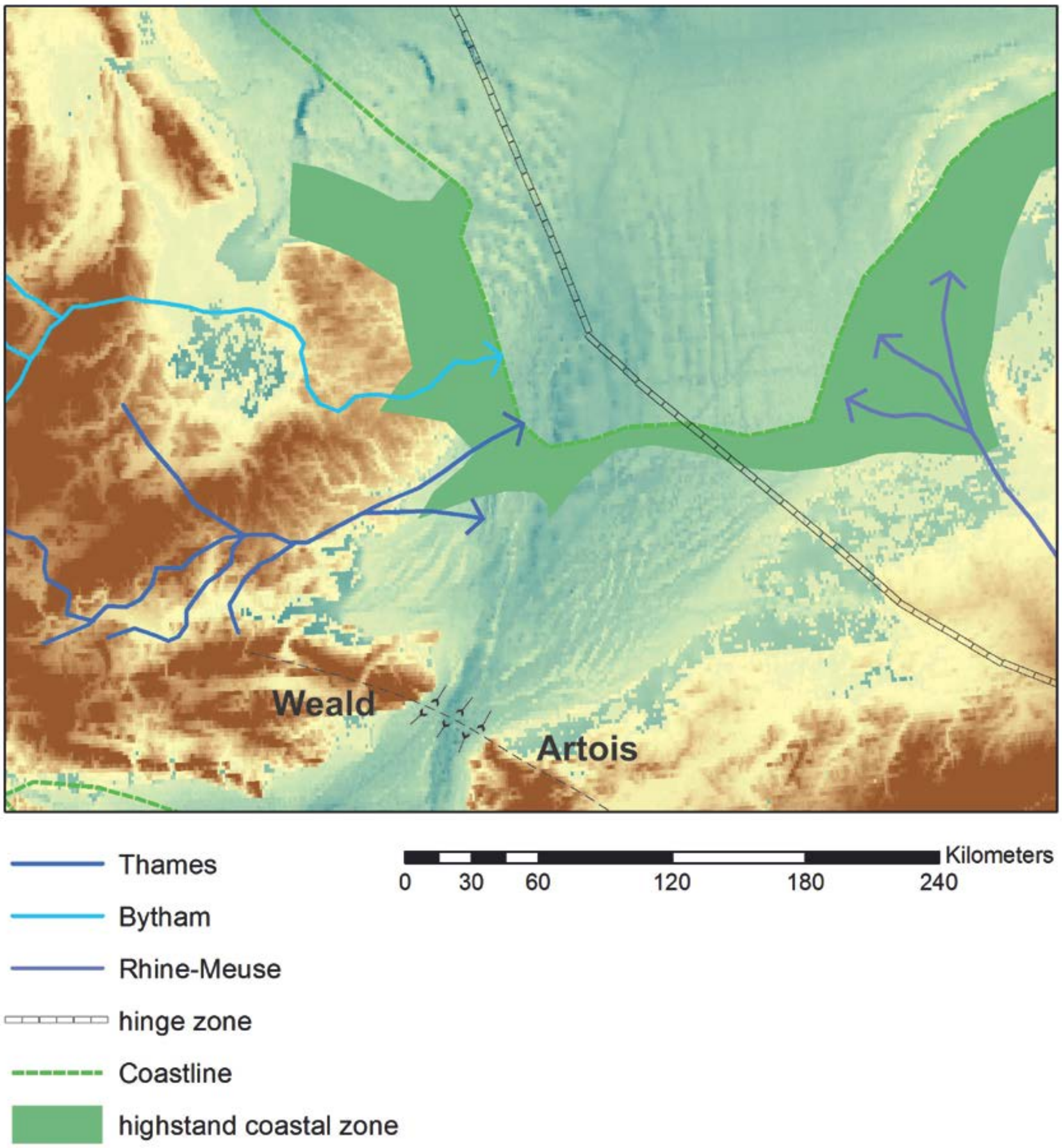

Figure 1.3 Major rivers and highstand coastal plain areas during the early Middle Pleistocene period (after Rose *et al.* 2001; Cohen *et al.* 2012; Hijma *et al.* 2012. Elevation data source: Smith and Sandwell 1997)

1.4 Questions

Assessing why we should attempt to use these areas, which are expensive to investigate and hard to reach, depends on the kinds of Palaeolithic questions where they have the potential to assist us. Given the role that the southern North Sea basin would have played in the occupation of North West Europe (Britain in particular, see Section 2.3) throughout the Palaeolithic, there are several key questions that research into the submerged zone can look to address:

- *With the potential for the existence of non-analogous environments, can we use the submerged material to redefine and further inform our current conceptions of the palaeoecological contexts of hominins throughout the Palaeolithic?*
- *Given that the pattern of occupation of Britain appears to be more sporadic than constant, can the inclusion of evidence from the southern North Sea aid our understanding of the patterning of hominin movements?*
- *Later Palaeolithic evidence shows that when marine resources are exploited they are exploited close to the shore. Are our preconceptions about a lack of early hominin coastal and marine adaptation and interactions therefore based on the invisibility of this record rather than its non-existence?*

With the current state of knowledge regarding the offshore record, however, we are nowhere near being able to address these questions. Can we therefore begin to address the lacunae in the current datasets that make them unanswerable? First, it is important to define what it is that the submerged zone can offer that terrestrial archaeology cannot. Aside from the fact that we should avoid automatically biasing our interpretations by knowingly ignoring a particular area of the Palaeolithic landscape, these areas have the potential to add significantly to the fragmentary evidence available from the terrestrial realm. Not only are we talking about a large area of low-lying, dynamic ecosystems, potentially rich in resources and with no modern analogue, but also coastal areas of the hominin landscape that we have little or no access to otherwise. These questions cannot be answered by looking at any other resource, and in the case of raised-beach deposits (which are the only other situation where we have access to the coastal record) have begun to provide evidence that is significantly altering the way we view past species' adaptations (Brown *et al.* 2011). We are currently missing the broader context of North West European hominin occupation; a huge swathe of complex and dynamic landscape, shallow coastline, estuaries and deltas. This was not a homogenous landmass any more than Britain is today, and to understand the capabilities of early hominins to survive at these latitudes we must also understand their contemporary ecologies. In order, then, to move our understanding of these submerged areas forward, these are the questions that this research will address:

- *What is the nature of these specimens and the deposits they are contained within?*
- *What do their distribution and patterning tell us about the offshore resource?*

This research aims to chip away at these questions through an investigation of the derived material that forms the bulk of the offshore archaeological record. In a similar way to the terrestrial work that has been conducted using derived lithics, a historical approach will be taken to the majority of these artefacts, which were largely collected throughout the 19th Century and where we have little information regarding their exact provenance. A combination of antiquarian letters, fishing charts and acquisition registers will be used to try to narrow these locations down as much as possible. The distribution of these artefacts will allow an examination of any patterning in the material that may indicate areas of Palaeolithic potential on the seabed, with further investigation leading to ground-truthing and practical engagement with these deposits.

The recovered material spans the Palaeolithic period and so this research presents the relevant issues relating to the study of submerged archaeology within the context of current Palaeolithic and associated geological research. Since the LGM has largely been the temporal ceiling for past research of submerged prehistory, this work will concentrate on the questions of the pre-LGM record. In addition to being far more invisible - from a current research point of view - this is a significantly different period in terms of the processes that have affected the record and therefore in the ways that we need to approach it. The nature of the majority of the record available will play a central role in this approach; with the non-site-based character of the archaeology lending itself to interpretations that draw from the continuous nature of the landscape, and the way in which these hominins inhabited it. Case studies will be presented, which will show how the use of material from extant deposits can begin to characterise these environments, developing new methods for understanding these landscapes.

1.5 Thesis Structure

The unorthodox nature of the material being examined in this thesis has led to a structure that is not standard. With specimens that encompass the entire Palaeolithic period, **Chapter Two** sets out the archaeological and environmental picture throughout this vast period from the early Middle Pleistocene through until the LGM. It first discusses the broad geological history of the southern North Sea, with landscape reorganisation and fluvial patterning being significant factors for hominin movements and subsistence. It then looks at the way in which we understand the chronology of the Palaeolithic, focusing on biostratigraphy because of the importance of faunal species as chronological indicators in this work. The patterning of changing archaeological signatures with relation to their corresponding environments will form the remainder of the chapter, drawing out pictures of presence and absence, related faunal communities and ecological preferences. These patterns of occupation and related mammalian assemblages will then be linked with patterning identified through the results of this research.

In terms of methodology, C**hapter Three** forms a discussion of the recovery of the specimens from the southern North Sea via the 19th and 20th Century trawling industry and introduces the faunal collections and main fishing ports. It focuses on fishing locations from each port, as well as information regarding the collectors themselves, in order to define areas of seabed that groups of specimens have derived from. It also discusses the development of trawling as an industry, both in terms of the technology and the social aspects, and how these may have affected the offshore record.

The areas of seabed defined within Chapter Three are applied to the analysis of the specimens in **Chapter Four**, which examines the distribution and patterning of the species from each distinct area. Both broad- and small-scale patterns are identified and it is argued that significant spatio-temporal patterning exists within the resource. To further test the potential of these methods and the robustness of the results, **Chapter Five** then uses two of the areas with small-scale patterns as case studies to investigate further with the addition of geophysical data for the most significant area.

Finally, **Chapter Six** pulls all of the themes that have emerged throughout the course of this research into a more in-depth discussion before **Chapter Seven** concludes and looks at the **further work** to be done.

Text Box 1: Offshore archaeological finds

Area 240

Discovered in the reject heaps of the SVB Flushing Wharf in Holland, 88 lithics (including 33 handaxes, 47 flakes and flake tools and 8 cores) were traced back to aggregate extraction Area 240, 11km off the coast of Great Yarmouth (Figure 1). The site, lying in approximately 30m of water, has also yielded a range of faunal material with species such as *Bison sp.*, *Mammuthus primigenius*, *Equus sp.* and *Rangifer tarandus.* Further investigations in the area have yielded more lithics, with the number now totalling 124.

Funding from English Heritage through the Aggregate Levy Sustainability Fund was obtained in order for Wessex Archaeology to conduct a project using geophysical, geotechnical and seabed sampling methods to characterise the site (Tizzard and Russell 2011). From this work, eight sediment units were identified ranging in date from Late Pliocene/Early Pleistocene through to marine deposits from the last (Holocene) transgression. Two channel features have been recognised which form part of the same Palaeo-Yare fluvial system. This was active in the area from the end of the Elsterian glaciation (MIS 12) and is here represented by fills dating to the late Elsterian (c.430ka) and the Early Holocene (c.7.8ka). Evidence from these deposits suggests that this location has repeatedly been in close proximity to the coastal zone throughout the Palaeolithic.

Evidence from the lithic typologies (Figure 2, Cordate handaxes, flakes as well as potential Levallois technique) and conditions, combined with sedimentology, has led to the conclusion that the *in situ* site (there are potentially lithics and fauna dating to other periods and of a re-worked nature) dates to approximately 250ka. This was based upon one of the units, Unit 3b (dated to between 350-200ka, MIS 8/7) being the source of the mint/fresh assemblage, a decision which was arrived at due to the presence of Levallois technique (so far confined to the early Middle Palaeolithic in Britain [Section 2.3.3]). The remainder of the deposits dated to either too early for this technique (Unit 2, >600ka, >MIS 13) or too late (Unit 5, c.40-30ka, MIS 3). It is important to note that the exclusion of MIS 3 was not purely typologically based but was also based on the type of deposit, being infilling of outwash plains channels and less likely to yield unabraded material.

Figure 2. Examples of lithic finds from Area 240 (source: http://www.wessexarch.co.uk/projects/marine/alsf/seabed_prehistory/area-240/artefacts)

Text Box 1: Offshore archaeological finds

Figure 1. Offshore archaeological sites

Area 240 represents the first *in situ* Palaeolithic site from the southern North Sea and demonstrates the potential of the area for furthering our understanding of the submerged landscapes of the Palaeolithic period. Being discovered by chance, the site also raises important issues regarding current approaches towards submerged archaeology, specifically that they are primarily finds-driven. Given the lack of opportunity to screen aggregate material prior to crushing, this significantly hinders our opportunity to investigate and understand the record (arguably a significant one [Hosfield 2007]) of the offshore extensions of Palaeolithic river terraces. Working towards a bottom-up, focused approach to these landscapes must therefore be a priority and is one which this research works towards.

Text Box 1: Offshore archaeological finds

Zeeland Ridges Neanderthal

In 2001 a fragment of frontal bone (Figure 3) was dredged from the Zeeland Ridges, 15km off the coast of the Netherlands (Figure 1). Associated with the fossil were the remains of Late Pleistocene fauna and Middle Palaeolithic artefacts such as bout coupé handaxes and Levallois flakes. Using 3D geometric morphometrics, and owing to the diagnostic nature of the frontal bone in hominins, the taxonomic affinity was defined as that of a Neanderthal.

Deriving from sand and shell extraction, the deposits have been refined to one of four extraction zones which occur within an area dominated by Early Pleistocene sediments, overlain by Eemian marine deposits which are incised by Weichselian channel fills. Two faunal asseblages have been recovered from this area, the first is characterised by Early Pleistocene species such as *Mammuthus meridionalis* (Southern mammoth) and *Homotherium latidens* (Sabre toothed cat) (van Kolfschoten and Laban 1995). The second is considerably later, consisting of Late Pleistocene species such as *Coelodonta antiquitatis* (woolly rhino), *Mammuthus primigenius* (woolly mammoth), *Panthera leo* (lion) and *Crocuta crocuta* (Hyeana). The Neanderthal fossil appears to fit well within this second group, given its degree of mineralisation, as do the Middle Palaeolithic lithic artefacts (Verhart 2004; Hublin et al. 2009).

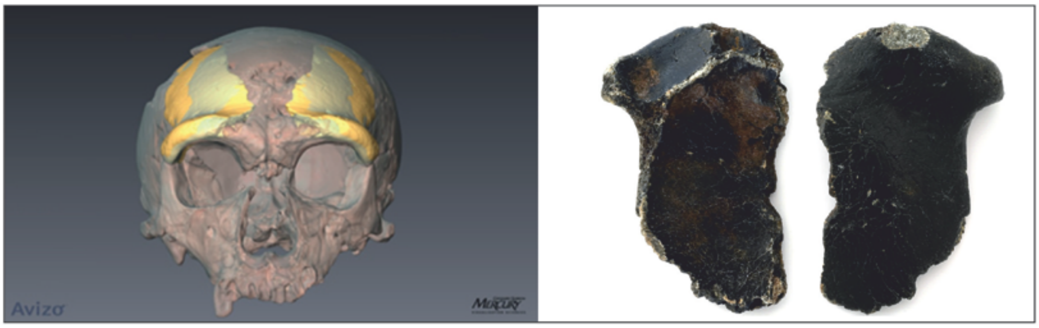

Figure 3. Zeeland ridges brow ridge, showing internal (left) and external (right) as well as the specimen mirror-imaged and super-imposed onto the La Chapelle aux Saints Neanderthal Skull (showing the left sinus of the La Chapelle specimen in red). Surface models are from CT scans. (From Hublin et al. 2009)

Recent research into the Pleistocene geological setting of this area of the southern North Sea (Hijma et al. 2012) indicates that the Zeeland ridges fossil was recovered from a deposit of shell-bearing sand belonging to the Rhine-Meuse braidplain that existed there during MIS 3, likely to be the offshore equivalent of onshore Unit B4, dated to 50-30ka (Busschers et al. 2007). These fossil bearing deposits owe their preservation to the repositioning of the Rhine-Meuse system 20km to the north, leaving these deposits to exist as an alluvial terrace, only moderately reworked by the subsequent Holocene transgression (Hijma et al. 2012).

Text Box 1: Offshore archaeological finds

Two features of the fossil were investigated, firstly isotopic analysis was conducted which revealed that this Neanderthal, like others that have been studied in the same way, was highly carnivorous (Bocherens et al. 2001; 2005; Richards and Schmitz 2008; Hublin et al. 2009). Secondly, a lesion on the bone was diagnosed as an epidermoid cyst, one of very few non-trauma related pathologies to be recognised in Neanderthal skeletal remains. This type of cyst (believed to form at birth) if its identification is correct, demonstrates the identical nature of modern human and Neanderthal embryogenesis.

Occurring within MIS 3, this find indicates Neanderthal occupation of north-west Europe in close proximity to other fossil bearing sites from this period (e.g. Spy, Belgium; Section 2.3.6, Figure 2.12) and is not only the first fossil from the Netherlands, but the first from the offshore zone. Given the rarity of fossil hominin finds from the terrestrial realm, this is extremely significant and demonstrates the amount of information that can be extracted from an isolated find.

Colinda Point

In 1931 the trawler *Colinda* recovered a barbed antler point (Figure 4) from the seabed 25 miles off the coast of Cromer between the Leman and Ower Banks (Figure 1 [Godwin and Godwin 1933]). In perfect condition, this 'harpoon point' has been dated to the Mesolithic period 10 - 4ka.

Being the first recognisably archaeological find from the offshore zone, the significance of the Colinda Point was that it brought the archaeological relevance of these areas to the attention of contemporary archaeologists. Although Reid had highlighted this 18 years earlier (Reid 1913), this find brought tangibility to Reid's more (archaeologically) abstract ideas.

Figure 4. Colinda Point (Photo: Antony Kelly. Source:http://www.edp24.co.uk/news/how_discovery_off_the_norfolk_coast_holds_the_key_to_norway_s_past_1_478824)

Chapter 2: Investigating the unconventional

An ecological approach to the Palaeolithic through the integration of submerged archaeology

Our understanding of the Palaeolithic, both Lower, Middle and Upper, is based on an extremely fragmentary dataset which we rely upon to answer big questions about the behaviour of our extinct hominin ancestors. It can be argued that our lack of engagement with the submerged landscapes of the southern North Sea, and the resultant void in information, present an avoidably large gap in our Palaeolithic knowledge of this region.

This chapter provides the backdrop to the study of these submerged landscapes and explores the current state of knowledge with regard to both the offshore zone as well as its terrestrial counterpart. It will argue that the picture of occupation of this region throughout the Palaeolithic is clouded by the exclusion of the invaluable resource of these submerged landscapes and that an unbiased understanding of the impact that they had on hominin movements, and on the record that we see in Britain, cannot be known without their exploration and inclusion. Given the temporal span of the material represented from this area, this work does not attempt to provide an in-depth assessment of the entire record, but rather to draw out the relevant issues, such as: the changing palaeogeographies of this area, the nature of hominin occupation through space and time and how these issues interrelate.

The ecological approach taken by this research views hominins and their environments as interlinked, where environments present constraints and opportunities within which fauna and flora, including hominins, exist and adapt (e.g. Butzer 1982). Adopting this approach means that an understanding of both the environments and the archaeological patterning throughout the Palaeolithic is crucial if we are to appreciate the variety of ecologies exploited and of the range of scales at which they can be viewed.

With common discrepancies between the environmental and archaeological resolution, as well as the non-organic nature of much of the Palaeolithic record, understanding the potential of varied ecologies for hominin subsistence can be extremely useful (e.g. the river valley subsistence of Brown *et al.* 2013). Whilst the offshore zone is currently characterised by faunal remains, as well as Quaternary deposit models and occasional geotechnical work, this type of work highlights the possibilities provided by a greater ecological understanding of these areas. Furthermore, given the importance of a bottom-up approach to the investigation of submerged landscapes over the longer term, being able to understand archaeological patterning within the context of changing ecologies and to use this to pinpoint areas of potential, is vital for the development of the discipline.

Conventions

Figure 2.1 introduces the various terms used throughout for defining chronology. The two main overarching terms used are 'Palaeolithic' and 'Pleistocene', which broadly correlate, the difference being that the first is an archaeological construct and the second geological. In terms of archaeological patterning, Section 2.3 sets out the earliest Palaeolithic as distinct from the Lower Palaeolithic, with the earliest occurring entirely during the early-Middle Pleistocene, with the Lower spanning MIS 13-9. From this point onwards, the archaeology is discussed in terms of the Palaeolithic: Lower Palaeolithic, Early Middle Palaeolithic, Late Middle Palaeolithic and Upper Palaeolithic. Since the archaeological signatures of the Lower Palaeolithic are found both sides of the Elsterian glaciation, a defining marker for faunal turnover, the species are discussed in terms of pre-Elsterian and post-Elsterian in order to make this distinction clear.

When it comes to further subdividing this period of time, the widely-used Marine Isotope Stages have been adopted (e.g. Shackleton 1987; Lisiecki and Raymo 2005). These are isotopically defined periods of time based on the records from marine core sediments and represent the broadest climatic capsules of time with which to look at glacial-interglacial stages for the Palaeolithic. Within each stage multiple fluctuations occur, becoming more rapid (or more apparent) through time (e.g. Dansgaard *et al.* 1993). These fluctuations are difficult to tie in with any specific archaeological sites because of discrepancies in dating resolution, but through the use of local pollen, molluscan and mammalian biostratigraphy, as well as lithostratigraphy, it is possible to recognise small-scale environmental changes that relate broadly to the contemporary archaeological picture.

In terms of dates used, when within the range of radiocarbon dating (i.e. approximately 50ka onwards), where possible the calibrated dates have been used (e.g. 36ka BP). This makes their correlation with other dating methods throughout earlier periods possible.

The European terms for the periods which correlate with these Marine Isotope Stages are used throughout the text and are shown in Figure 2.1. The European as opposed to British terms for glacial and interglacial stages have been used so as to highlight the continuous nature of the landscape throughout most of the period in question.

Figure 2.1 Conventions and terms used throughout the text

2.1 Palaeogeography: placing the archaeology in the context of landscape and movement

Current evidence from the site of Happisburgh 3, Norfolk, points to the earliest occupation of Europe north of the Alps being at approximately 900ka on the western edge of the southern North Sea in East Anglia (Text Box 2 [Parfitt *et al.* 2010]). This discovery, coming soon after that of nearby Pakefield (c.700ka [Parfitt *et al.* 2005]), has begun to rewrite our understanding of the early hominin occupation of Europe, highlighting the great time-depth that we are dealing with. This research, concentrating on the periodically terrestrial landscapes of the southern North Sea, therefore addresses a period of close to a million years, with this section concentrating on the palaeogeographical context of these episodes of occupation.

The seeming remoteness of the landscapes that once existed in the southern North Sea often makes it difficult to perceive them as dynamic and heterogeneous. However, understanding these changing landscapes has important implications for how we think about occupation patterns through time as well as hominin adaptations to changing ecologies. Broadly speaking, a range of environments would have existed, some of which we may have no modern analogue for and thus no way to understand them other than through their direct investigation. Pleistocene coastal environments, for example, are predominantly now submerged, as are the lowest reaches of the major river systems and the associated ecotones of the estuaries. Similarly, some areas of higher ground from earlier periods have been eroded away (Gibbard 1995; Clayton 2000; Toucanne *et al.* 2009; Hosfield 2011), leaving their exploitation by hominins as merely theoretical.

Text Box 2: Pakefield and Happisburgh 3

The site of **Pakefield** is situated on the Suffolk coastline (Figure 2.6) in what has been lithologically defined as the floodplain sediments of the lower reaches of the now extinct Bytham River (Parfitt *et al.* 2005) and is found within the organic sediments of the CFbF. The environment was one of modern Mediterranean temperatures (mean warmest month temperature of 18-23°C and mean coldest month temperature of -6 - 4°C [Atkinson et al. 1987; Parfitt et al. 2005]), attested to by the presence of species such as *Hippopotamus* and frost sensitive insects as well as thermophilous beetles such as *Oxytelus opacus* that no longer live in such northerly latitudes (Parfitt et al. 2005).

The sediments that the lithics were contained within were overlain by glacial Lowestoft Till (here assigned to MIS 12 but cf. Lee et al. 2004), the presence of which, combined with AAR (Penkman et al. 2011), palynology, mammalian biostratigraphy (eg. The presence of the vole *Mimomys savini* rather than *Arvicola terrestris* [Figure 2.5]) and palaeomagnetism (Parfitt et al. 2005) has placed the site at 680ka (MIS 17) – 750ka (MIS 19).

The flint assemblage is made on good quality black flint and includes one crudely retouched flake, a flaked core and debitage (n=32). The other raw materials in the river catchment are predominantly quartz and quartzite and the natural sides of the flint stone tools show evidence of water abrasion which indicates that they too probably came from the river gravels. Though none of the flints are less than 20mm, it is not a large assemblage and this further supports the assumed fluvial source of the raw material. A further important point about this site is that the artefacts were recovered from four different contexts, indicating that hominins were a relatively regular occurrence in the landscape: two from the 'rootlet bed' (overbank sediments), a single flake from the laminated silts at the edge of the channel, another single flake from the upper levels of the estuarine silts (this was the oldest archaeological level, with more marine influence) and the remainder from the lag gravel at the base of the laminated silts (these fill the channel which cuts into the overbank sediments).

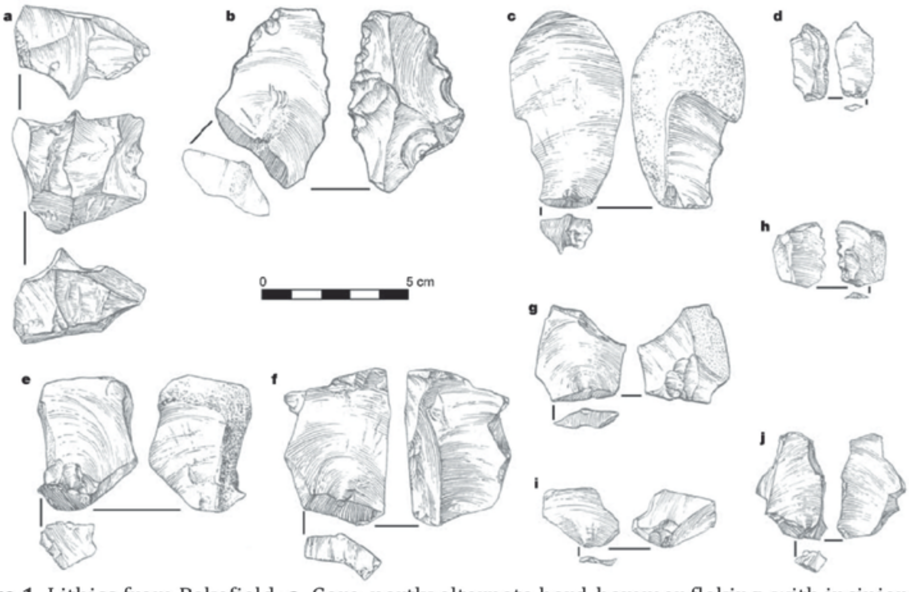

Figure 1. Lithics from Pakefield: **a.** Core, partly alternate hard-hammer flaking, with incipient cones of percussion on platforms. **b,** Retouched flake. **c-j**, Hard hammer-struck flakes, with previous removals on dorsal surface, often from the same direction.
Locations: b, 'Rootlet bed'. **C,** Laminated silts. **a, d, j**, Lag gravel. (after Parftt et al. 2005)

Text Box 2: Pakefield and Happisburgh 3

Happisburgh 3 significantly pushes back the occupation of north-west Europe to within the Early Pleistocene, and as such is the earliest record of occupation north of 45 degrees (Parfitt et al. 2010). As with Pakefield, it formed on the lower reaches of the floodplains of what is believed to have been within the estuary of the pre-diversion Thames, which had input from the upstream confluence of the Bytham River.

The lithic assemblage (n=78) at this site is similar to Pakefield in that it is made from flint and contains no handaxes. However, a significant difference is the high number of large flakes (up to 145mm) and flake tools in the assemblage. The large nature of the lithic assemblage makes the lack of handaxe technology more conspicuous than it does at Pakefield and Parfitt *et al.* (2010) suggest that these larger flakes indicate that the material for manufacture was selected and knapped elsewhere and that they were brought to the site for use. Similarly to Pakefield, the lithic assemblage is largely unabraded, suggesting minimal fluvial transport or disturbance prior to their deposition. Furthermore, they are present in several levels indicating repeated visits to the site.

The lithics were recovered from fluvial gravels interstratified with estuarine sands and silts, all of which underlie the Happisburgh Till (MIS 12). Pollen sequences from this site and from a nearby borehole (1966 [West 1980]), indicate an Early Pleistocene date through species such as *Tsuga* (hemlock) and *Ostrya* (hop hornbeam) that are unknown after this time (Coxon and Waldren 1997). The occurrence of *Mammuthus meridionalis* and the vole *Mimomys savini* (as at Pakefield) further place this site towards the Early Pleistocene. The interpretation that the site was forming on the edge of the boreal zone comes from plant macrofossils (eg. *Pinus cf. sylvestris*) and beetle remains at the site; occupation within the climatic optimum prior to this period has yet to be demonstrated (Preece and Parfitt 2012).

Through the combination of palaeoenvironmental and biostratigraphical with palaeomagnetic data, Happisburgh 3 is thought to lie within the late stages of the Matuyama Chron and to be between 970 - 814ka; significantly earlier than any other British Palaeolithic site (Parfitt et al. 2010). Both its lithic assemblage and palaeoenvironmental settings make it an extremely interesting case study into early hominin adaptations and have brought new questions to bear on our understanding of early hominin dispersals throughout northern Europe.

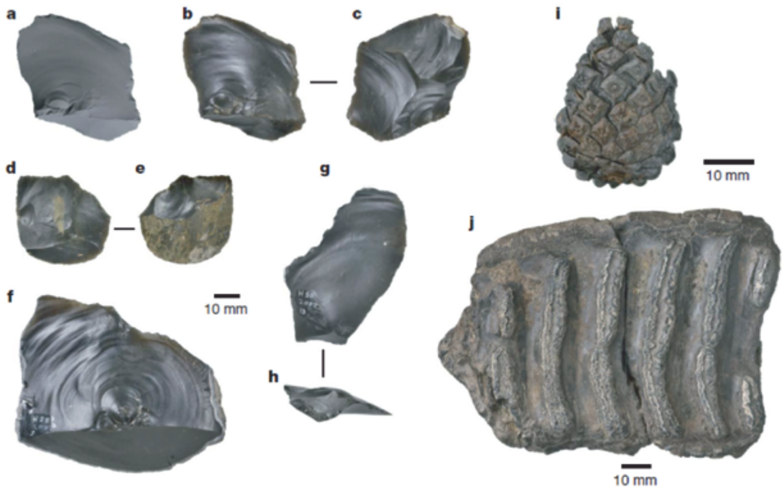

Figure 2. Recovered artefacts and biological remains from Happisburgh 3. **a-c**, hard hammer flake. **d, e**, multiple notch. **f,** hard hammer flake. **g, h**, hard hammer flake showing pronounced point of percussion on plain butt. **i**, cone of *Pinus cf. sylvestris*. **j**, upper second molar of *Mammuthus meridionalis* (after Parfitt et al. 2010)

2.1.1 Landscape reorganisation

During the early Middle Pleistocene (c.780ka – 450ka), the most significant of these areas of higher ground in southern Britain was a chalk bedrock interfluve (the Weald-Artois ridge) which ran across the Dover Straits, linking Britain to the continent and creating a variable, shallow marine embayment of the southern North Sea (Figure 2.1). The area to the west of the Dover Strait was dominated by The Channel River, fed by fluvial systems such as the proto-Somme, Seine and Solent (Gupta *et al.* 2007). The existence of this higher ground had implications for landscape organisation as well as the movement of fauna and flora as it would have meant that constant interchange was possible. Presumably this would also have been an attractive place to be situated, overlooking expanses of lower ground as well as being at the ecotone between several environments: fluvial, terrestrial and shallow marine. However, the build-up of a pro-glacial lake during the Elsterian glaciation (also Anglian, MIS 12, c. 478Ka, Figure 2.1), bounded in the south by this chalk anticline, eventually led to its catastrophic breaching (Gibbard 1995; Gupta *et al.* 2007; Toucanne *et al.* 2009), the ensuing landscape reorganisation having a significant impact on the geographies and environments of the entire North Western peninsula. The timing and nature of this breach are therefore very important, but the scales at which we recognise these processes are frustratingly at odds with the archaeological resource, providing us with often confusing and conflicting stories.

At the earliest point of occupation (early Middle Pleistocene) Britain was permanently joined to the European continent throughout both cold and warm climatic stages. Sea levels of course fluctuated throughout this period, in response to both global eustatic changes (eg. Lambeck *et al.* 2002) as well as sedimentation from the major European rivers that drained into what was then a North Sea embayment (Cameron *et al.* 1992; Bridgland and D'Olier 1995; Funnell 1995; Gibbard 1995; Meijer and Preece 1996; Rose *et al.* 1999, 2000, 2001; Bridgland 2000; Toucanne *et al.* 2009a; Hijma *et al.* 2012). However it was not until the major glaciation of the Elsterian and the first coalescence of the Fennoscandinavian and British ice sheets that this situation began to change (Toucanne *et al.* 2009a). Evidence of glaciolacustrine sediments in the southern North Sea, which date to the Elsterian glaciation and form part of the tripartite Swarte Bank Formation (SBF [Long *et al.* 1988]), point to the formation of an extensive lake at the foot of the glacier from a combination of glacial meltwater and outflow from the impounded northward-draining rivers, bounded in the south by the Ridge (Gibbard 1995; 1998; Murton and Murton 2012). High-resolution swath bathymetry data of the seabed immediately to the south of the Dover Straits (and throughout the Channel) indicates that the breaching of this ridge was catastrophic and suggests that it was caused by the eventual overtopping of this North Sea lake (Gupta *et al.* 2007), with bench morphology signifying that this overtopping may have occurred twice (*ibid.*). Given the lithostratigraphic evidence as well as evidence from the eroded sediments being deposited distally in the Bay of Biscay it seems highly likely that the initial breach occurred during the Elsterian glaciation (Long et al 1988; Toucanne *et al.* 2009a, 2009b). A second major breach is argued to have taken place during MIS 6, based on proglacial fluvial sediments from the Rhine-Meuse in the Netherlands (Busschers *et al.* 2008), as well as faunal evidence pointing to a full marine connection from MIS 5e onwards (Preece 1995). Debate is ongoing as to the nature and the timings of these events (see for example Westaway and Bridgland 2010 and Toucanne et al. 2010). However, despite these disagreements, what is clear is that the Elsterian glaciation marks the start of a major reorganisation of the drainage patterns and geography of the North Western peninsula of Europe throughout the Middle to Late Pleistocene.

The status of Britain's connection to the continent has implications for hominin movements and the resultant archaeological signatures that we see. Without a terrestrial connection, groups of hominins would either not have been able to move into Britain, or would have become isolated and potentially locally extinct, as indeed would the contemporary fauna and flora. The timing of the terrestrial connection has therefore been the subject of hypotheses attempting to understand the hypothetical impact of these cyclical changes (e.g. Ashton and Lewis 2002; White and Schreve 2006; Ashton and Hosfield 2010; Ashton *et al.* 2011; Pettit and White 2012). However the actual evidence, both archaeologically and environmentally, is often fragmented and unclear. This is especially true for earlier periods, whose deposits have been subjected to repeated changes in sea level and, in places, glaciations.

Further difficulties arise when attempting to superimpose past eustatic sea-level data onto the modern bathymetry of the southern North Sea in order to define island/peninsula status. This is due to the bathymetry having seen significant alterations through time because of erosion, subsidence, burial and the impact of crust-depressing ice sheets. As well as erosion and burial of deposits and topographic features, the difficulties of understanding glacio-isostatic adjustment (GIA) for periods before the Last Glacial Maximum are compounded by the lack of extant deposits that can be correlated enough to provide chronologically secure and accurate information on relative sea levels throughout the Pleistocene.

The North Sea is within an area of tectonic subsidence that has been active since the Oligocene (Cloetingh *et al.* 2006), with the hinge zone running approximately along the East Anglian coastline (Hijma *et al.* 2012). Although this means that the deposits have escaped the major erosional processes associated with tectonic uplift, and also the burial processes of the depo-centre, the deposits are generally stacked with little vertical separation (Rose 1999; 2001), making it extremely difficult to discern relative dates and lateral cohesion. Consequently what we can discern from these deposits about the palaeogeographies of these areas throughout the Palaeolithic is at two differing scales: at the very local scale there can be fine-grained palaeoenvironmental reconstructions, but our understanding of the wider landscapes is generally far coarser.

Recent work on the formation and deposits of the southern North Sea has drawn together several lines of research looking at the changes to the landscape throughout the Pleistocene (Cohen *et al.* 2012; Hijma *et al.* 2012). The evolution of the fluvial systems that developed in this section of North West Europe throughout the Pleistocene also impacted greatly on the formation of the contemporary landscape and has seen work on both sides of the North Sea (Bridgland *et al.* 1993; Bridgland and D'Olier 1995; Funnell 1996; Roe 1999; Rose *et al.* 1999; 2001; Antoine *et al.* 2003; Bridgland 2000; 2003; 2006; 2010; Busschers *et al.* 2005; 2007; 2008; Kemna 2008; Westerhoff *et al.* 2008; Toucanne *et al.* 2009a, 2009b; Roe *et al.* 2009; Rose 2009; Westerhoff 2009; Roe and Preece 2011; Roe *et al.* 2011).

2.1.2 Fluvial landscapes

Over 90% of Palaeolithic archaeology in Britain, as well the northern European coastal zone has been found contained within river terraces (e.g. Wymer 1999; Ashton and Lewis 2002; Brown *et al.* 2013). Whether this is a response to the preservation conditions that fluvial/floodplain environments offer, the modern exploitation of gravel pits, a reflection of actual hominin preference or, most likely, some combination, this means that understanding these fluvial systems is crucial for understanding the Palaeolithic world.

The formation of the fluvial terraces that contain this archaeology is naturally an important issue and, whilst these processes may differ depending on the types of landscape processes dominant in different areas (e.g. Bridgland and Westaway 2008), a scheme has been developed for the Middle and Lower Thames which allows terraces to be distinguished and defined (Text Box 3, Bridgland 1994, 2000; Maddy *et al.* 2000; 2001; Westaway *et al.* 2002; 2003). This has meant that the contained archaeology, whether *in situ* or derived, can be assigned a degree of chronology and context (Bridgland 1994; Hosfield 1999; Brown et al 2009). Text Box 3 describes this process as defined for the Lower Thames. It is important to be aware, however, that this process does not appear to work for all terrace systems (Brown *et al.* 2010) including those of the upper Thames (Bridgland 1994).

Traditionally thought of as impossible to use in any meaningful and secure way, recent work (Hosfield 1999; Hosfield and Chambers 2004; Howard *et al.* 2007; Brown *et al.* 2010; Basell and Brown 2011; Brown *et al.* 2013) has focused on the application of this vast archive and has dealt with the principle of whether it is possible to 'tack' between the large-scale, coarse-grained information contained within these terraces and the fine grained, '15 minute' episodes represented by *in situ* sites such as Boxgrove (Wylie 1993, 24; Gamble 2001; Hosfield 1999; 2005). Understanding the processes which modified the lithic assemblages, as well as the post-depositional implications for the artefacts arising from differences in the dynamics of river systems, are both extremely important for deciphering how far these assemblages have moved and the levels of information they contain (Hosfield 1999; Brown *et al.* 2013).

Recent work has demonstrated that much of the secondary context lithic resource has not moved a significant distance, often despite rolled or abraded appearances (Basell and Brown 2011; Brown *et al.* 2013). Despite its coarse nature the secondary-context archive can therefore provide insights into large-scale changes in the archaeological signature, including changes in population densities (Ashton and Lewis 2002), first appearances or absences of hominins in the landscape, and the introduction of new technologies (e.g. Levallois at MIS 9/8; Bridgland 2001; Westaway *et al.* 2006; Scott 2006; Bolton 2010; Scott 2011).

2.1.2.1 Pleistocene fluvial systems of the southern North Sea

There are several interrelating factors that affect the behaviour of fluvial systems. Sea level plays a significant role in controlling the base level of the system that controls the level to which the river can erode (Schumm 1993). The degree of sediment supply in relation to sediment removal affects the gradient of the system and is largely controlled by climate-related factors; glacial periods result in a decline or even total lack of vegetation growth, which leads to increased sediment input from unstable banks. Conversely, in interglacial periods vegetation locks-up the river bank material, which leads to increased river-bed incision. Furthermore, the deposition of fluvial sediments on the continental shelf leads to isostatic uplift of associated upland areas (Westaway *et al.* 2002), all of which plays a part in the formation of the river terraces so important to Palaeolithic archaeology (Text Box 3).

The changing dynamics displayed through extant fluvial sediment stratigraphies allow us to infer at least broad palaeoenvironmental changes through geological time. For example, the southern North Sea has acted as a depocentre for rivers flowing through Britain and North West Europe throughout the Pleistocene period (although only intermittently after the Elsterian glaciation [Westaway and Bridgland 2010]), the final output of these rivers fluctuating in relation to the ever-changing coastlines. The extant deposits from these rivers provide us with information, albeit fragmentary, about their catchments and changing energy levels through their unique lithological signatures.

The dominant rivers flowing into the southern North Sea throughout the Palaeolithic were far from static. The Thames, originally flowing out of north Norfolk during the Early Pleistocene (Rose 1999; Parfitt *et al.* 2010), was gradually diverted south before being pushed into its current course after the Elsterian Glaciation, whilst palaeo-rivers such as the Bytham and Ancaster were obliterated (Figure 2.2; Rose *et al.* 1999; Clayton 2000). Another major European river supplying sediment to the southern North Sea basin includes the Rhine-Meuse system (Bridgland 2000, 2002; Busschers *et al.* 2005; 2007; Figure 2.2) which, during the early-Middle Pleistocene, had its river mouth on the north-eastern extent of the southern North Sea (Hijma *et al.* 2012). Its associated formation in the Netherlands is known as the Sterksel Formation and represents a period of significant basin-ward progradation of the major rivers in this area (*ibid*.; Zagwijn 1989; Westerhoff 2009). Contemporary with and to the west of this formation are the offshore deposits of the Yarmouth Roads Formation, the onshore Cromer Forest-bed Formation (CFbF, Text Box 4) and shallow marine Wroxham Crag Formation (Rose *et al.* 2001).

In contrast to the pre-Elsterian situation, fluvial sedimentation in the southern North Sea after the Elsterian glaciation is intermittent (Westaway and Bridgland 2010). This probably reflects the altered drainage route of the major fluvial systems through the (at least partially) opened Dover Straits (Gupta *et al.* 2007; Westaway and Bridgland 2010) and results in a less extensive record of deposits in this area. In addition, the terrestrial record from eastern England after the Elsterian glaciation was far less influenced by fluvial activity, with this being replaced by glacial terrain (e.g. Blakeney Esker, Cromer Moraine [Rose 2008] and the formation of small landforms, such as the lake deposits at Hoxne, which developed on the glacial landscape [West 1956; Singer *et al.* 1993]) and smaller river systems driven by glacial relief and sub-glacial melt-water drainage routes. These smaller fluvial systems were less well organised. In contrast with the lithologically uniform pre-Elsterian fluvial and crag deposits, however, they had far more complex sedimentologies, which formed far less coherent parts of the landscape (Rose 2008). Rivers such as the Trent/River Witham, draining out of the Wash Basin (Bridgland 2010; White *et al.* 2010), the Palaeo-Yare (associated with Area 240 [Text Box 1]), Waveney (Mathers *et al.* 1993; Wymer 1999), Thames

(Bridgland 1994; 2000; 2004) and Medway (Bridgland 1988; Bridgland *et al.* 1999) formed post-Elsterian fluvial systems along the East Coast of England, their terraces providing much of the associated Palaeolithic archaeology (Wymer 1999).

After the Elsterian no glaciation covered the southern North Sea, or came further south than the Midlands (Figure 1.2, although see Beets *et al.* 2005 for possible glaciation in the Southern Bight area). This is reflected by the paucity of glacial-associated deposits in the UK sector. Saalian pro-glacial lake deposits are found in the northern part of the southern North Sea (north of 53°) but with only 2m – 8m of thickness (Cameron *et al.* 1992). However, during these periods (as well as 'failed interglacials' such as MIS 3 [Section 2.3.4]), the southern North Sea would have been dry land, with the most extreme low-stands seeing sea level drops of >100m below modern sea level (Busschers *et al.* 2007). The unusually large expanse of continental shelf in North West Europe means that during these periods there was increased opportunity for the development of fluvial systems converging across these landscapes. A good example is that of the Channel River (or Fleuve Manche [e.g. Antoine *et al.* 2003; Toucanne *et al.* 2009a]) which saw input from French rivers such as the Seine and Somme, English rivers such as the palaeo-Solent and Thames, and continental rivers such as the Rhine-Meuse (although input from this system is not without debate [Oele and Scuttenhelm 1979; Gibbard 1995; 1998; Lericolais 1997; Lericolais *et al.* 1997; Petit-Maire 1999; Bridgland 2002]).

Given the relatively continuous nature of fluvial terraces throughout the Pleistocene, and the fact that >90% of Pleistocene rivers have extended onto the shelf (Bridgland 2002), these low-stand systems may provide us with much archaeological and environmental information about the Pleistocene of the submerged zone. Because of subsequent marine erosion as well as the practicalities of offshore imaging, however, they are difficult to reconstruct and investigate. Furthermore, given that the main source of geophysical and geotechnical exploration of these deposits is by aggregate-extraction companies, the information is often sensitive and restricted.

These restrictions do not always hold true, and the use of industry-collected 3D seismic data has recently shown the preservation of a large area of submerged Late

Pleistocene/Early Holocene landscape in the area of the Dogger Bank (Gaffney *et al.* 2007; 2009), with a dynamic range of landscapes recognised. Further to the south and on the other side of the southern North Sea basin, the extensive deposits of the Rhine-Meuse system have been mapped through from the Early Pleistocene (Hijma *et al.* 2012) demonstrating the changing landscapes through processes such as progradation and subsequent erosion. Associated with this system are the intriguing finds of the Zeeland Ridges Neanderthal (Hublin *et al.* 2009, Text Box 1), demonstrating the worth of understanding these deposits from an environmental point of view, as well as contextually for associated archaeological finds.

As one of the major fluvial systems draining into the southern North Sea throughout the Pleistocene, the offshore Thames-Medway terraces have been mapped through seismic profiling to investigate their low-stand expressions (D'Olier 1975; Bridgland *et al.* 1993). Three buried channels have been recognised and it has been suggested that they represent cold-stage gravels from MIS 6, 4 and 2. They appear to run east and south into the Southern Bight, where considerable dissection has occurred through subsequent marine transgression (Figure 1.1; Bridgland *et al.* 1993). This appears to indicate the existence of post-Elsterian fluvial systems draining through the eroded Dover Straits during low-stand conditions.

Low-stand periods were not the only points at which terrestrial deposits were forming in the now offshore zone. Due to changing palaeogeography and corresponding relative sea levels, even during some of the highest post-Elsterian sea level interglacials (for example the Eemian), parts of the eastern British coastline extended further east than they do today (Figure 2.2). Examples of these from offshore eastern Essex are the Clacton Channel system, which can be demonstrated to extend into the offshore zone and represents fluvial deposition during the first post-Elsterian interglacial (MIS 11, Holstenian [Bridgland et al. 1999; Roe and Preece 2011]), the Cudmore Grove Channel, which shows estuarine conditions during the interglacial conditions of MIS 9 (Schreve *et al.* 2002; Roe *et al.* 2009; Roe *et al.* 2011; Roe and Preece 2011) and the East Mersea Restaurant Site, whose Eemian fluvial deposits are now buried by beach shingle (Roe and Preece 2011). Further evidence for Eemian fluvial deposits in areas now submerged comes from geophysical and geotechnical investigation of a multi-period fluvial system off the coast of Essex, as part of the Outer Thames Regional Environmental Characterisation (REC) project (Dix and Sturt 2011 [see Chapter Five for further discussion of the deposits in this area]).

Text Box 3: River Terrace Formation

Understanding the development of fluvial terraces has implications for the archaeological and environmental chronology of the Pleistocene, since they contain the vast majority of the Palaeolithic archaeology in Britain and the coastal areas of northern Europe (Wymer 1999; Ashton and Lewis 2002; Brown et al. 2013).

A previous model of terrace formation supposed that during times of low sea level, rivers would have further to flow to reach the coastline which would therefore result in down-cutting and the production of a new terrace. However, it was soon realised that in each glaciation, instead of re-cutting a new, lower path, rivers would simply re-occupy their previous course. Work by Bridgland on the Lower Thames (1994; 2000; 2006) led him, and colleagues (Maddy et al. 2000; 2001; Westaway et al. 2002; 2003; 2006) to developed a model that directly links the MI stages to terrace development and to large scale climate change as preserved in deep sea cores.

Their work in the Lower Thames Valley led to a scenario where uplift plays an important role in the formation of terraces (Figure 1): The transition from glacial to interglacial would result in increased levels of erosion, which would in turn transport and deposit greater amounts of material onto the continental shelf. The upper crust is thicker at the continental shelf than in inlands areas and so a pressure gradient already exists. At times of equilibrium (stable periods such as the middle of an interglacial or glacial period) deposition of eroded sediment is negligible, so the amount of molten rock forced inland due to the gradient is extremely low. During transitional times of high erosion (**Phases 1 and 2**), however, a larger amount of sediment is deposited on the continental shelf, causing it to subside. The crust beneath the inland, eroding areas respond to this by moving upwards, thus increasing the pressure gradient further. This increase in gradient forces more molten rock from the continental shelf inland, resulting in crustal thickening and an uplift of the corresponding landmass. This is further compounded by the sediment unloading of the eroding areas; which adds to the net uplift. Critically, these transitional phases will result in higher levels of erosion due to several factors:

- Movement from a glaciation to an interglacial will see an increase in disturbed weather patterns such as storms and flooding events, resulting in higher levels of erosion.
- These cooler periods will be less conducive to vegetation growth, which plays an extremely important role in binding the soil matrix together to prevent it from eroding. Vegetation-free banks in these periods will therefore be much more susceptible to erosion.
- Freeze-thaw action will further help to destabilise the river banks.
- The melting of perma-frost and glaciers will cause a large discharge of high energy water with strong erosive powers.

These processes of uplift and erosion lead to downcutting through the previous interglacial floodplains, the edges of which are left as terraces (**Phase 1**). Furthermore, not all of the eroded material will be moved downstream, but a thin layer of cold-stage material will be deposited across the base of the fluvial system (**Phase 3**).

Once climate is ameliorated, weather patterns even-out and vegetation begins to secure the river-banks. This is a period of little erosion, most of which will happen within the channel, moving existing sediments downsteam and resulting in the deposition of fine-grained sands and silts (**Phase 3**).

The transition to cooler conditions towards the end of the interglacial period once again sees more unstable weather conditions and possible erosion within the channel (**Phase 4**). Due to (assumed) progressive uplift, however, Phase 4 is also accompanied by minor downcutting resulting in a series of widely spaced and narrowly spaced (formed during Phase 4) terraces. As climate deteriorates further and the vegetation begins to die-off, this, along with and the beginnings of freeze-thaw action, leads to the erosion of banks and slopes and an increase in sediment within the river system, resulting in the main phase of aggradation (**Phase 5**). Due to the minor downcutting associated with Phase 4, this aggradation generally fails to reach the height of the interglacial deposits at the valley-side margins

Text Box 3: River Terrace Formation

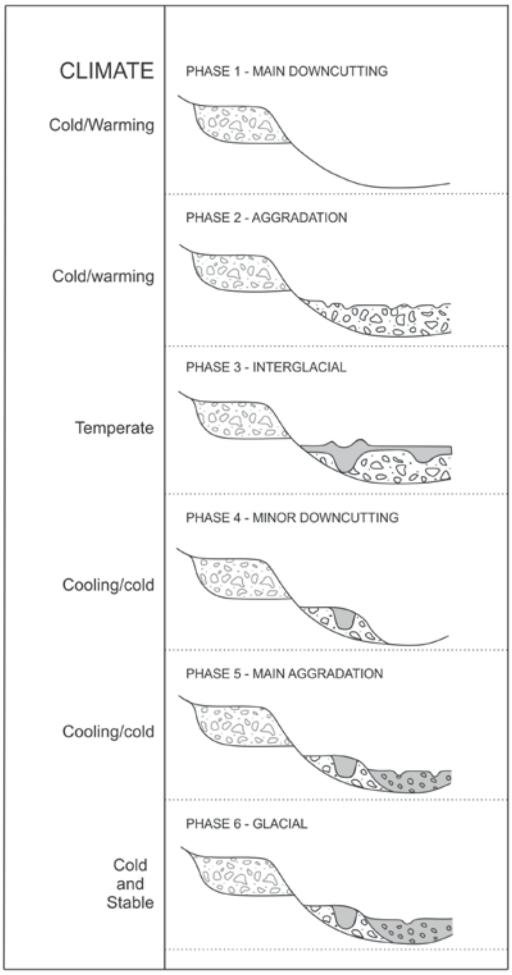

Figure 1. Terrace formation phases (Bridgland 2006)

(although cold-climate gravels are found superimposed on-top of these deposits further from the valley edge). Finally, **Phase 6** represents full glacial conditions with minimal erosion or deposition.

So in this case, climate is driving high-energy erosion and hence is playing a part in terrace formation and the vegetational response to the climatic regime is reinforcing this; linking MIS glacial cycles with more localised climate-driven changes. However, terrace formation can also be affected by mechanisms like glacio-isostacy which can cause complicated patterns of uplift and subsidence on a regional scale (Bridgland 2000).

Terrace formation will be affected differently in different areas and there is by no means one clear model of how they are formed. For example, fluvial systems in subsiding areas such as the eastern Netherlands lead to stacked terrace sequences (Bridgland 2000; 2010). This particular model therefore fits the Lower and Middle Thames Valley (cf. Gibbard 1985; 1995; Gibbard and Lewin 2002; Lewin and Gibbard 2010) but current research is working on its application elsewhere (Brown et al. 2009; 2010; Ashton and Hosfield 2010).

Further mapping of offshore deposits has recently taken place through another of the REC projects, this time of the East Coast (Limpenny *et al.* 2011). This project has provided a further level of detail to that of the preceding British Geological Survey work during the 1970s and 80s (Cameron *et al.* 1992) and demonstrates how extrapolating from widely spaced geophysical lines can introduce interpretative error and smooth over detail.

There is clearly a wealth of Pleistocene deposits in the southern North Sea, albeit fragmentary (as they are terrestrially), and the landscapes of the southern North Sea and surrounding areas throughout the Palaeolithic were clearly very different from the way we think of them now. This is especially so during the early-Middle Pleistocene when they were dominated by large rivers and sea embayments. This therefore returns us to the question of our perceptions of these landscapes and of how contemporary hominins would have engaged with them. Returning to the broader research questions outlined in Chapter One, can investigation of these deposits shed light on the differing ecologies of these now offshore areas and, if so, can we relate this back to hominin engagement and preferences? The identification of these deposits is a necessary first step in this process, but further exploration (or direct investigation, for example of over-sized aggregate such as that which led to the discovery of Area 240 [Text box 1]) is required if we are to start addressing archaeological questions.

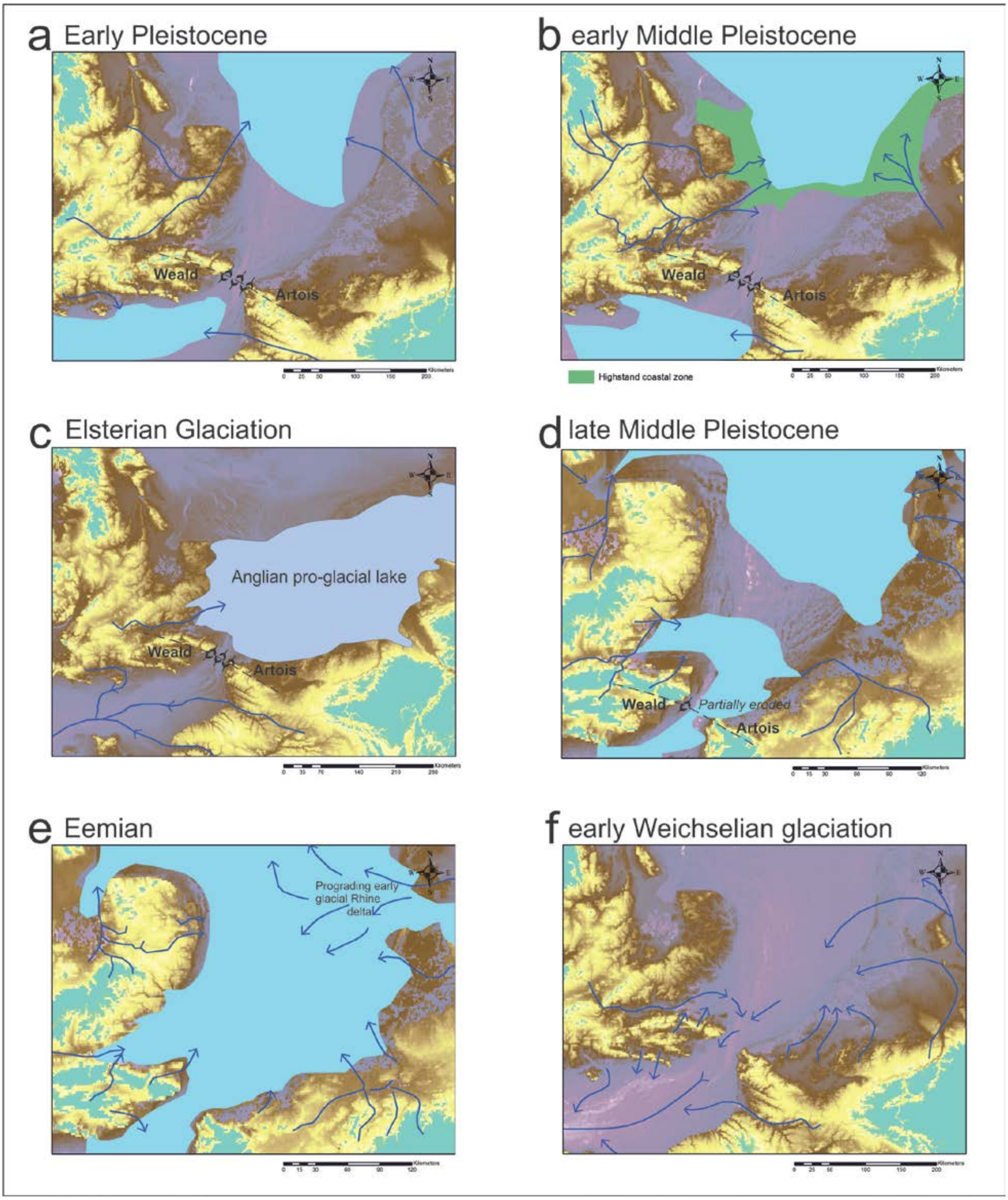

Figure 2.2 Changing position of rivers and sea levels through the Pleistocene. a: Early Pleistocene (after Parfitt *et al.* 2010); b: early-Middle Pleistocene, also showing highstand coastal zone (after Rose 1999; 2001; Hijma *et al.* 2012), c: Elsterian cold-stage, showing the pro-glacial lake build-up (after Parfitt *et al.* 2010; Murton and Murton 2012), d: Late Middle Pleistocene, showing a partially eroded Weald-Artois ridge but the possible existence of an area of terrestrial land to the north-east is shown, made up of till sheets in

its northwestern extent and Palaeogene outcrop in its southeast extent. Modest marine exchange was possible with overtopping (after Hijma *et al.* 2012), e: Last Interglacial, showing the marine highstand and a prograding Rhine delta in the northeast (after Hijma *et al.* 2012), f: early Weichselian low-stand landscape, showing rivers flowing south into the Channel River (After Gibbard *et al.* 1988; http://www.qpg.geog.cam.ac.uk). (Elevation data source: Smith and Sandwell 1997)

2.1.3 Linking fluvial and shallow marine sequences

The unique lithologies and sedimentation patterns of each river can inform us about the general climatic processes prevailing throughout the relevant catchment. However, it is only really through the joint study of related deposits that a wider picture emerges. This has been highlighted, for example, through looking at the most extensive Early- early Middle Pleistocene deposits in Britain, which occur in East Anglia. The changing dominance of lithologies within the shallow marine Wroxham Crag members (early Middle Pleistocene) has been used to infer the dominance of the ancestral Thames system over the Bytham at that time (Rose *et al.* 2001) and the identification of these deposits within exposed sections has further allowed the details of the course of the systems to be mapped more fully.

Given the shallow gradient of East Anglia and the southern North Sea, oscillations in the relative sea level in this area are likely to have been fairly noticeable (Nicholls 2010), with the deposition of shallow marine interspersed with organic floodplain sediments demonstrating these fluctuations (Rose *et al.* 2001). It is impossible to divorce the fluvial deposits from the marine crag deposits in this area; sediment input from the varied catchments of the rivers is present within the crag deposits and allows us to correlate the two through lithological comparisons (Figure 2.3).

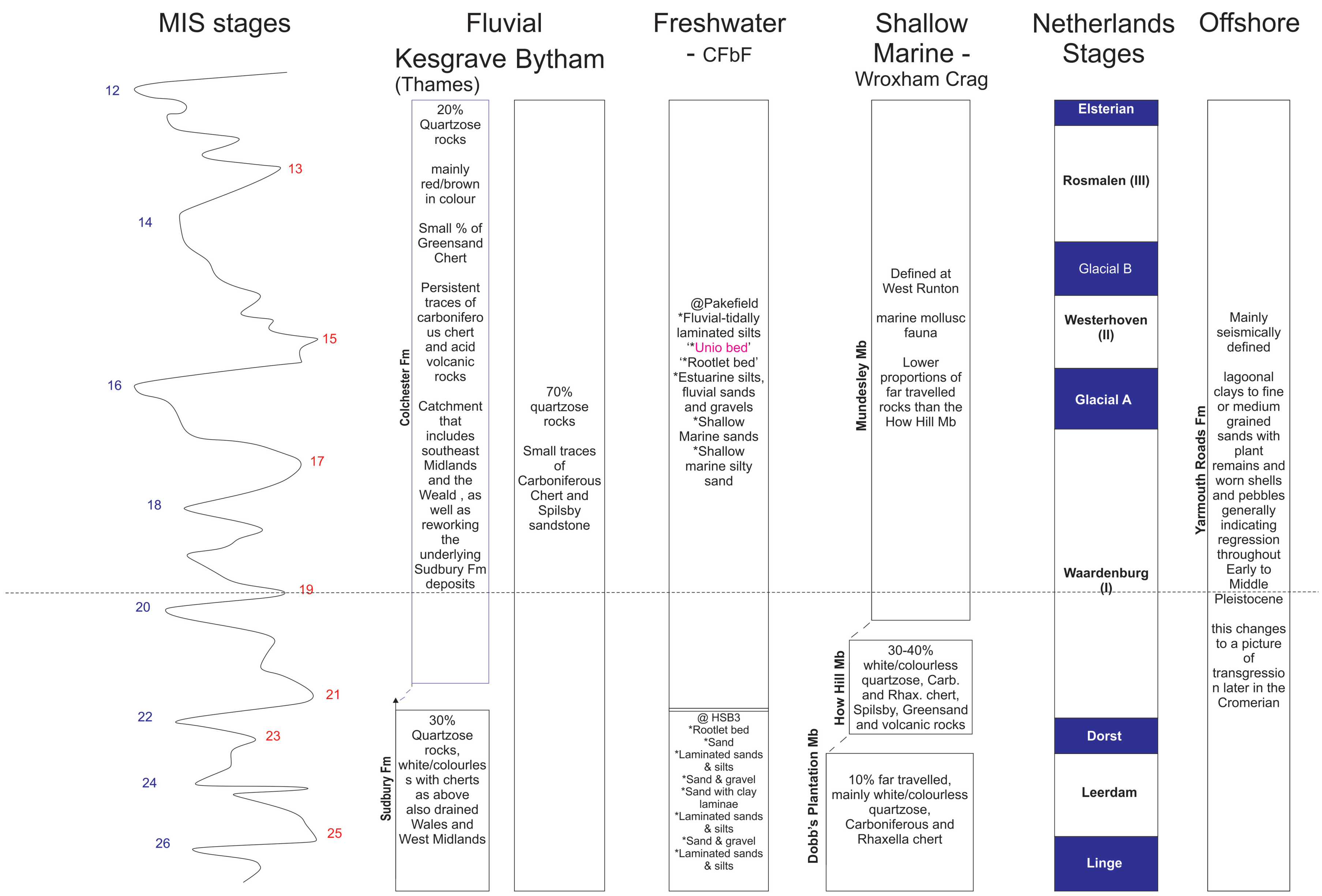
MIS stages
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
Fluvial
Kesgrave Bytham
(Thames)
Colchester Fm
20% Quartzose rocks
mainly red/brown in colour
Small % of Greensand Chert
Persistent traces of carboniferous chert and acid volcanic rocks
Catchment that includes southeast Midlands and the Weald , as well as reworking the underlying Sudbury Fm deposits
Sudbury Fm
30% Quartzose rocks, white/colourless with cherts as above also drained Wales and West Midlands
70% quartzose rocks
Small traces of Carboniferous Chert and Spilsby sandstone
Freshwater
- CFbF
@Pakefield
*Fluvial-tidally laminated silts
'*Unio bed'
'*Rootlet bed'
*Estuarine silts, fluvial sands and gravels
*Shallow Marine sands
*Shallow marine silty sand
@ HSB3
*Rootlet bed
*Sand
*Laminated sands & silts
*Sand & gravel
*Sand with clay laminae
*Laminated sands & silts
*Sand & gravel
*Laminated sands & silts
Shallow
Marine -
Wroxham Crag
Mundesley Mb
Defined at West Runton
marine mollusc fauna
Lower proportions of far travelled rocks than the How Hill Mb
How Hill Mb
30-40% white/colourless quartzose, Carb. and Rhax. chert, Spilsby, Greensand and volcanic rocks
Dobb's Plantation Mb
10% far travelled, mainly white/colourless quartzose, Carboniferous and Rhaxella chert
Netherlands
Stages
Elsterian
Rosmalen (III)
Glacial B
Westerhoven (II)
Glacial A
Waardenburg (I)
Dorst
Leerdam
Linge
Offshore
Yarmouth Roads Fm
Mainly seismically defined
lagoonal clays to fine or medium grained sands with plant remains and worn shells and pebbles generally indicating regression throughout Early to Middle Pleistocene
this changes to a picture of transgression later in the Cromerian

Figure 2.3 lithologies and stages of the early Middle Pleistocene in East Anglia (after Cameron *et al.* 1992; Rose *et al.* 1999; 2001; Zagjwin 1989)

Analysing and correlating the currently onshore and offshore components of these deposits is key to understanding the landscapes in their original context, but at present this is fraught with difficulties. The Wroxham Crag, for example, is defined through its lithological components (Rose *et al.* 2001) and is made up of shelly sands, gravels and muds formed over a period of approximately 1.4Myr (Rose *et al.* 2001). Its earliest deposits therefore lie outside the current date-range of occupation, but many of those that are younger are extremely relevant archaeologically (Figure 2.3, e.g. Parfitt *et al* 2005). Its deposits represent what were, during the Pleistocene, shallow marine environments, as demonstrated by the presence of marine molluscan faunas (Rose *et al.* 2001).

Offshore the deposits are defined on a predominantly seismostratigraphical basis (i.e. through geophysical imaging), ground-truthed by occasional boreholes and cores, and they have been defined over a short period, relative to the length of time for which the currently terrestrial deposits have been investigated. Furthermore, the investigation of the two areas has been undertaken separately, and this results not only in the emergence of different terminology for onshore as opposed to offshore deposits, but in a difference in the recorded detail. For example, the onshore deposits that relate to the early Middle Pleistocene period include several facies of both the CFbF and the Wroxham Crag, such as the Mundesley member of the Wroxham Crag or the Pakefield Member of the CFbF, whereas offshore these deposits are referred to simply as the Yarmouth Roads Formation (Cameron *et al.* 1992), simplifying the offshore deposits and hindering the integration of the two zones (Figure 2.4).

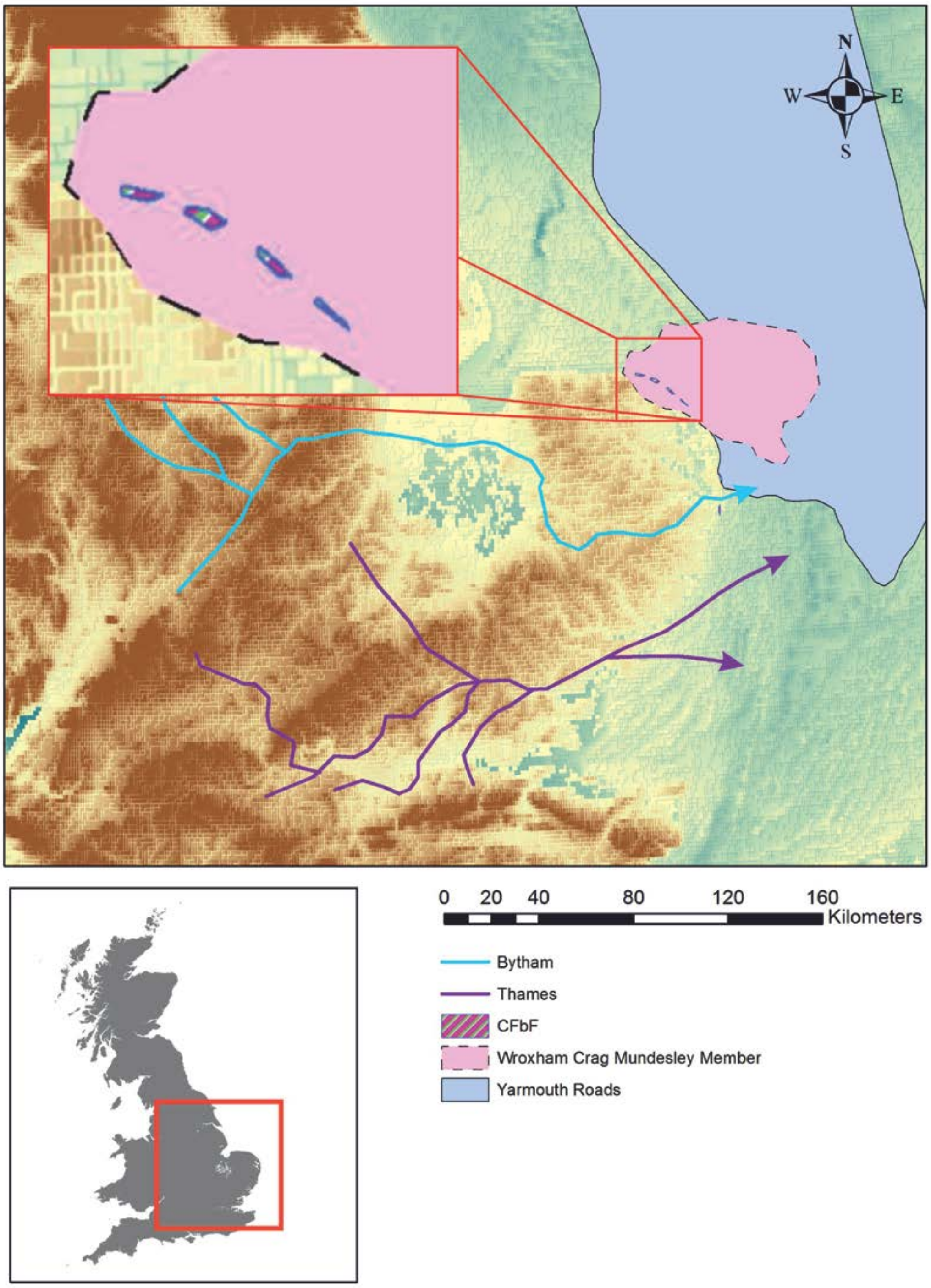

Figure 2.4 location of CFbF onshore and the corresponding locations of the Yarmouth Roads and Wroxham Crag Formations offshore (after Cameron *et al.* 1992; Rose *et al.* 2001. Elevation data source: Smith and Sandwell 1997)

The few boreholes that sample the Yarmouth Roads Formation (Cameron *et al.* 1992; Limpenny *et al.* 2011) allow correlation with the onshore Ormesby borehole

(Harland *et al.* 1991) as well as outcroppings of Wroxham Crag along the coastline and in quarry sections. Importantly, the Yarmouth Roads Formation represents deposits which formed under both terrestrial and shallow marine conditions during the Pleistocene and are now submerged offshore. The distinction between the two is not however defined as it is for the currently terrestrial deposits of the CFbF and Wroxham Crag, which formed under the same terrestrial and shallow marine conditions respectively.

Importantly, the input that we see in fluvial and related shallow marine deposits from their catchment areas can help to define the environmental processes at the time. Let us take the Wroxham Crag again as an example. In the case of the earliest member, Dobb's Plantation, clast sizes and the proportions of allochthonous to autochthonous rocks indicate that the rivers were then transporting bedload from throughout their catchments. This contrasts with the preceding period of the Early Pleistocene Norwich Crag, where bedload was predominantly local, with far-travelled components represented solely as suspended sediment. This indicates a larger catchment area (Rose *et al.* 2001; Rose 2008; Lee *et al.* 2008). The change reflects a fundamental shift in the dynamics of the river systems of southern Britain and has been linked to intensified climatic changes from the Middle Pleistocene onwards (*ibid;* Rose 2010). With this intensification, periglacial processes became part of the dominant climatic repertoire and coarse-grained materials began to be eroded and transported around the landscape; bedload and palynomorphs from all areas of the river catchments define the lithologies of these periods and allow us to reconstruct the migrations and energy levels of the major fluvial regimes.

2.1.4 Summary

Given the amount of archaeology contained within river terraces, their formation is an important consideration for the chronology of the artefacts they contain. The work on the Lower Thames brings a varied degree of chronological control over fluvial terraces (Bridgland 1994; 2000; Maddy *et al.* 2000; 2001; Westaway *et al.* 2002; 2003; Bridgland and Westaway 2008), combined with recent work drawing out the significance and wealth of information contained within these (often) derived assemblages (Hosfield 1999; Hosfield and Chambers 2004; Howard *et al.* 2007; Brown *et al.* 2010; Basell and Brown 2011; Brown *et al.* 2013). The potential for applying these combined techniques to submerged deposits is clear.

Despite the likelihood for disturbed offshore deposits, especially further to the east (Bridgland *et al.* 1993), these techniques demonstrate how we can link offshore terrace deposits, even where disturbed, back in with the archaeological picture (Hosfield 2007), and so address questions about the occupation of the submerged zone.

2.2 Patterns and chronologies

The Palaeolithic of Britain, and to a lesser degree North West Europe, is generally characterised by a pattern of discontinuous occupation, with an extremely ephemeral Early Pleistocene presence (Dennell 2003; Parfitt *et al.* 2010; Voinchet et al 2010). Although from approximately MIS 13 (528-478Ka) onwards there is a significant increase in the numbers of sites, apparently decreasing again from MIS 10 (c.364Ka) (Ashton and Lewis 2002; McNabb 2007; Lewis *et al.* 2011; Ashton and Lewis 2012; Pettit and White 2012), chronological resolution often means that it is very hard to place these sites accurately within specific periods of interglacial-glacial cycles. Identifying what assemblage density at these younger sites actually means for occupation (re-occupation of a site or an intensive afternoon's knapping [Ashton and Lewis 2002]) is a further problem when thinking about what these patterns represent, as the two scenarios have different implications for hominin behaviour within these landscapes.

Chronological control of the Palaeolithic record therefore necessarily relies on taking a multidisciplinary approach, to piece together evidence such as dating techniques (e.g. Walker 2005; Penkman 2005; Penkman *et al.* 2007; 2011), lithostratigraphy and pollen/mammalian biostratigraphy. Despite the availability of an array of techniques (especially the recent developments in OSL and AAR for earlier parts of the Palaeolithic [Walker 2005]) this section will focus on biostratigraphy (primarily mammalian), as it is faunal specimens that form the basis of the chronological framework adopted by this research in Chapters Four and Five.

Biostratigraphy, in its various forms, is an extremely important component in the environmental reconstruction of Pleistocene sites and underpins much of what we understand about the formation and character of these landscapes (e.g. it underpins the chronologies of the river terrace formation model [Bridgland 1994; 2000; 2006; Maddy *et al.* 2000, Bridgland and Westaway 2008]). However, it is important to recognise the limitations implicit in considering assemblages that may be representative only of a local environment, and of species that may be spatially restricted or diachronous across continents. This becomes ever more important with Britain's increasing insularity, as, in the Later Pleistocene, we begin to see what look like impoverished 'island' faunas and floras (Currant and Jacobi 2011).

Biostratigrahical groupings are most reliable when they include several lines of evidence - mammalian, pollen and molluscan, for example - and many stages within interglacial-glacial sequences are characterised in terms of these specific assemblages (e.g. Preece and Parfitt 2000; 2012). The Holstenian (Hoxnian) interglacial (broadly correlated with MIS 11) has been characterised primarily through its palynology at the sites of Hoxne and Marks Tey (Turner 1970), with complex stages and substages acknowledged (Turner 1970; Ashton *et al.* 2008). Further supporting environmental characterisation has been acquired from mammalian and beetle remains (Coope 1993; Stuart *et al.* 1993). Of course, the development of an interglacial stage is often very similar from one interglacial to the next and the taxa involved may make it difficult to distinguish distinct marine isotope stages. MIS 11 and MIS 9, for example, have very similar biostratigraphical signatures, and differentiating one from the other generally relies on several lines of evidence (Schreve 2001; Roe and Preece 2011) and often comes down to absolute dating techniques (generally with errors in the 10kys (Grun and Schwarcz 2000) and relative dating techniques such as Amino Acid Racemisation (AAR e.g. Penkman 2005; Penkman *et al.* 2011).

On the other hand, some interglacial/glacial periods are characterised by very distinct biostratigraphical signatures. The Last Interglacial/Eemian (MIS 5e) for example, is characterised by an absence of *Abies, Equus* and *Corbicula fluminalis* and the presence of *Hippopotamus.* Similarly, at the site of Happisburgh 3, the discovery of the Early Pleistocene species *Tsuga* (hemlock) and *Ostrya*-type (hop-hornbeam type) combined with other lines of biostratigraphical and palaeomagnetic data helped to place the site in the Early Pleistocene (Parfitt *et al.* 2010; cf. Westaway 2011).

Given the range of environments where archaeological sites are found, biostratigraphical evidence is not always preserved, but sites of purely environmental data are used instead, in an attempt to slot the sites into a likely environmental picture. Marks Tey (Turner 1970), for example, has no associated archaeology but forms a continuous sequence throughout the MIS 11 interglacial, and provides the backbone of our knowledge about the changing environments throughout this time. Similarly, most of the fluctuation within the early Middle Pleistocene is defined on the basis that mollusc, pollen and faunal data (Preece and Parfitt 2012) can help to inform where the sporadic archaeological sites are situated chronologically. However, although these techniques are undeniably important, there are risks with extrapolating interglacial characteristics from a single depositional environment. Types of pollen will disperse at varied rates and over varied differences; these problems of abundance are well studied (Vera 2000). It is the absence of taxa however that can be problematic. It was long thought that MIS 3 was characterised by an absence of tree cover (Coope *et al.* 1997; Coope 2002), a view heavily supported by molluscan and insect evidence, but more recent work by Caseldine *et al.* (2008) at Lancaster Hole has reliably demonstrated a dominance of arboreal pollen (Pettit and White 2012, 314). Whilst this does not by itself render previous interpretations incorrect, it should remind us that basing region-wide reconstructions on localised sequences is likely to over-simplify a reality that is more complex.

2.2.1 Mammalian biostratigraphy

Mammalian biostratigraphy is based on understanding the taxonomic evolution of species and uses first- and last-appearance dates (Preece *et al.* 2009; Preece and Parfitt 2012). Distinguishing specific periods within the early Middle Pleistocene is problematic at present because of a lack of chronological control over deposits (cf. Penkman *et al.* 2011, with a relative AAR dating framework). For this period, then, mammalian biostratigraphy is based on informally-defined groups of important micro-and macro-fauna, such as the evolution of the water vole *Mimomys savini* to *Arvicola terrestris cantiana* and the presence of certain species of mammoth (e.g. *Mammuthus meridionalis* [Lister and Bahn]) and deer (e.g. *Cervus savini* [Lister *et al.* 2010]) (Preece and Parfitt 2000; 2012). However, for the Middle and Later Pleistocene a series of formal Mammal Assemblage Zones have been published (Figure 2.5 [Schreve 2001; Currant and Jacobi 2001; 2011]). Although these examples are not exhaustive or infallible, they provide a useful starting point for the types of groupings of fauna that are representative of certain interglacial-glacial stages. In terms of this research, they also form a reference for the potential ages of the specimens being recovered from areas of the seabed.

There are twelve Mammal Assemblage Zones (MAZs) identified for the Middle and Late Pleistocene in Britain which, when compared with the North Western European counterparts provide interesting inferences about Britain's peninsular status (Schreve 1996; 1997; Schreve *et al.* 2002; Currant and Jacobi 2001; 2011). Figure 2.5 shows a list of these MAZs along with a list of fauna that are present or absent throughout these periods. Although there are breaks in the lines, indicating absence, it is possible that particular fauna are simply not represented by present knowledge. This comes back to issues of basing an evidence of absence on an absence of evidence, and of extrapolating faunal assemblages from one distinct site over entire landscapes.

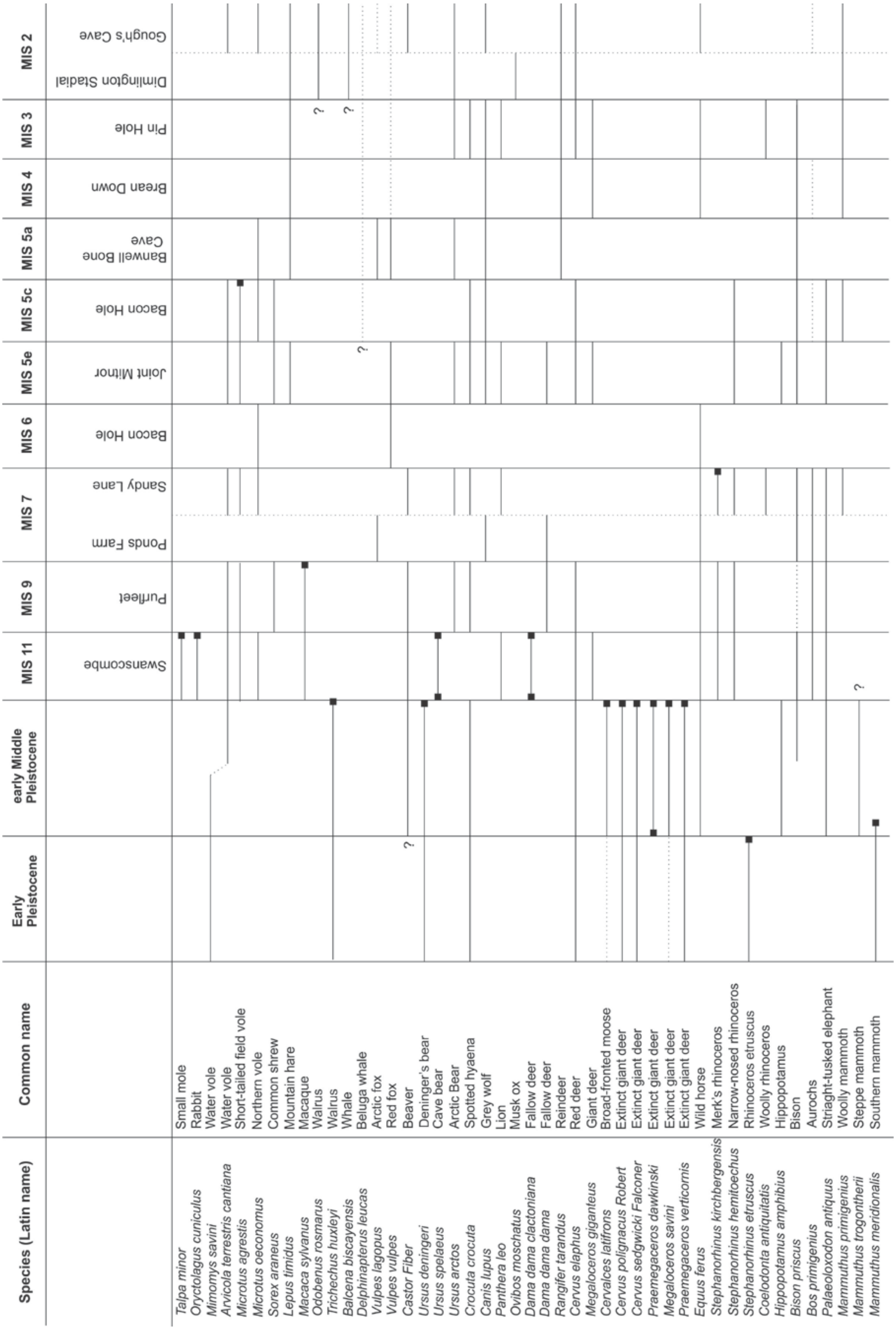
Species (Latin name)
Common name
Early Pleistocene
early Middle Pleistocene
MIS 11
Swanscombe
MIS 9
Purfleet
MIS 7
Ponds Farm
Sandy Lane
MIS 6
Bacon Hole
MIS 5e
Joint Mitnor
MIS 5c
Bacon Hole
MIS 5a
Banwell Bone Cave
MIS 4
Brean Down
MIS 3
Pin Hole
MIS 2
Dimlington Stadial
Gough's Cave
Talpa minor
Oryctolagus cuniculus
Mimomys savini
Arvicola terrestris cantiana
Microtus agrestis
Microtus oeconomus
Sorex araneus
Lepus timidus
Macaca sylvanus
Odobenus rosmarus
Trichechus huxleyi
Balcena biscayensis
Delphinapterus leucas
Vulpes lagopus
Vulpes vulpes
Castor Fiber
Ursus deningeri
Ursus spelaeus
Ursus arctos
Crocuta crocuta
Canis lupus
Panthera leo
Ovibos moschatus
Dama dama clactoniana
Dama dama dama
Rangifer tarandus
Cervus elaphus
Megaloceros giganteus
Cervalces latifrons
Cervus polignacus Robert
Cervus sedgwicki Falconer
Praemegaceros dawkinski
Megaloceros savini
Praemegaceros verticornis
Equus ferus
Stephanorhinus kirchbergensis
Stephanorhinus hemitoechus
Stephanorhinus etruscus
Coelodonta antiquitatis
Hippopotamus amphibius
Bison priscus
Bos primigenius
Palaeoloxodon antiquus
Mammuthus primigenius
Mammuthus trogontherii
Mammuthus meridionalis
Small mole
Rabbit
Water vole
Water vole
Short-tailed field vole
Northern vole
Common shrew
Mountain hare
Macaque
Walrus
Walrus
Whale
Beluga whale
Arctic fox
Red fox
Beaver
Deninger's bear
Cave bear
Arctic Bear
Spotted hyaena
Grey wolf
Lion
Musk ox
Fallow deer
Fallow deer
Reindeer
Red deer
Giant deer
Broad-fronted moose
Extinct giant deer
Extinct giant deer
Extinct giant deer
Extinct giant deer
Extinct giant deer
Wild horse
Merk's rhinoceros
Narrow-nosed rhinoceros
Rhinoceros etruscus
Woolly rhinoceros
Hippopotamus
Bison
Aurochs
Striaght-tusked elephant
Woolly mammoth
Steppe mammoth
Southern mammoth

Figure 2.5 Defined MAZs present through Middle and Later Pleistocene periods (after Schreve 2001; 2004; Currant and Jacobi 2001; 2011;) and faunal species present during the pre-Elsterian, Early – early Middle Pleistocene (after Lister *et al.* 2010; Breda *et al.* 2010; Preece and Parfitt 2012). Black squares indicate the First Appearance and Last Appearance dates of species, where known.

Some of the interesting patterns that may be discerned relate to the isolation of Britain from MIS 5e through until MIS 4. MIS 5e appears to be the first interglacial to demonstrate continued isolation from the continent, with the absence of Rhenish molluscan fauna (Meijer and Preece 1995). A reconnection is not likely until the cold of MIS 4 ([e.g. Keen 1995], although we must recognise the possibility of certain species to make shorter sea crossings during the lowered sea levels of MIS 5d and 5b [Currant and Jacobi 2011]). Consequently there appears to be an increasing impoverishment in interglacial fauna throughout this period (Currant and Jacobi 2011). This contrasts with the picture to the south, specifically in regions such as Picardie (Northern France: Locht 2005), which have several sites yielding fauna from MIS 5c and MIS 5a, including species such as *Coelodonta antiquitatis* (woolly rhinoceros), *Equus ferus* (horse) and *Mammuthus primigenius* (woolly mammoth) (Simonet 1992). Combined with the picture of hominin absence from this period (but see Wenban-Smith *et al.* 2010 for possible evidence of occupation), this evidence does appear to indicate an island status for Britain throughout this time. Access to Britain would therefore have been impossible without a sea crossing and any hominins existing there before the rise in sea level would have faced isolation and potential local extinction.

The stratigraphic relationship of a site with the broader landscape is also a vital tool for placing it in relative date order, so long as we have a good understanding of the emplacement and taphonomy of the deposits. An example of the complexities of this issue can be found in the early Middle Pleistocene environments of East Anglia. Here, the fortuitous capping by Elsterian till (a combination of the North Sea Drift Formation and the Lowestoft Formation) of many of the early Middle Pleistocene deposits has not only led to their preservation, but provided them with a known age-marker., Understanding the ages of these markers is not necessarily straightforward, however. This has been demonstrated by a recent debate over the age of the till deposits, with recent British Geological Survey (BGS) lithostratigraphic mapping suggesting that the earlier till deposits were emplaced during an earlier MIS 16 glaciation (Hamblin *et al.* 2000; Lee *et al.*, 2004a,b, 2006a, 2008a; Hamblin *et al.*, 2005; Rose, 2009; Candy *et al.*, 2006) and that the various tills represent glaciations from MIS 16 through to MIS 6. This does not, however, agree with biostratigraphic (Preece 2001; Stuart and Lister 2001; Preece and Parfitt, 2008; Preece *et al.* 2009), aminostratigraphic (Preece *et al.* 2009; Penkman *et al.* 2011) or lithostratigraphic (Hoare *et al.* 2005; 2006; Lewis and Hoare 2012) evidence, all of which place all till deposits within MIS 12. There are problems in assuming that lithostratigraphic markers (or the lack of) defined at singular points of a spatially and temporally variable deposit will be representative of the whole deposit (Bose *et al.* 2013). This highlights the difficulties of understanding complex landscape (in this case, glacial) processes from such fragmentary and dispersed deposits.

2.2.2 Summary

Chronological resolution for the Palaeolithic relies heavily on non-archaeological proxies, with that most relevant to this research, mammalian biostratigraphy, being discussed above. As Lang and Keen (2005) state (although referring to the use of secondary-context material), much Palaeolithic archaeology is "most profitably viewed through the multidisciplinary prism of Quaternary Science, in which archaeology and the environment form an interlinked whole". This is true, but there is also the question of scale, and whether these proxies are understood at a scale relevant to one another. Issues of resolution plague the Palaeolithic, especially the earlier record, and it is often the case that extremely localised, high-resolution environmental records allow us to understand snapshots of these periods, but that these records are then confusingly at odds with the archaeological record that could often feasibly have been deposited over several episodes of occupation. Several lines of biostratigraphical, lithostratigraphical and archaeological data are, where possible, combined in order to deal with these issues, and for the most part these limitations simply need to be explicitly recognised so that we can extract an appropriate amount of data from the record. Therefore, although this record is inherently fragmented, there is an ever-increasing amount of information that can be derived from it, with the inclusion of the offshore record potentially representing a step-change in the amount and nature of the information available.

2.3 The changing archaeological record

2.3.1 The earliest Palaeolithic (early Middle Pleistocene: c.780 – 478ka)

The constant exchange of fauna and flora that was possible throughout the early Middle Pleistocene (Cameron *et al.* 1992; Gibbard 1995; Toucanne *et al.* 2009a; Hijma *et al.* 2012; Murton and Murton 2012) had important implications for the dispersal of early hominin species, although to what degree these once-terrestrial landscapes were exploited remains unknown. This section will explore the picture of occupation of Britain and North Western Europe through the early Middle Pleistocene until the arguably different picture of MIS 13, which here will be taken as the start of the traditional Lower Palaeolithic.

2.3.1.1 Environmental context

Understanding the environments of the Palaeolithic often relies on evidence from single, well-preserved sites being correlated and extrapolated to much larger regions. The picture for the early Middle Pleistocene of Britain is no exception, but relies on a far more laterally-extensive, high-resolution deposit from the coast of East Anglia: the CFbF (Textbox 4 [Preece and Parfitt 2000, 2012]).

Providing an unprecedented expanse of Pleistocene deposits to investigate, the CFbF allows a detailed examination of environments at points throughout the early Middle Pleistocene, even though these are generally no more than relative in date to one another (e.g. Preece and Parfitt 2012).

The early Middle Pleistocene comprises four interglacial phases (MIS 13-19) and two glacial phases (MIS 14 and 16, although neither of these periods saw lowland Britain glaciated [cf. Lee *et al.* 2004]). All of these phases have traditionally been thought of as less extreme than the succeeding Pleistocene stages (MIS 12-1

[Section 2.1.2]), with no interglacial periods reaching the warmth of the Holocene (Flower *et al.* 2000; EPICA 2004). This would mean that hominins inhabiting these environments would have to have been able to cope with much cooler environments than the apparently balmy Hoxnian of MIS 11 (Ashton *et al.* 2008). However, having the detailed record of the CFbF for this period allows the global ice core record to be tested at a local scale.

Despite the detail of the CFbF, the vertical separation of the deposits it contains is negligible (Rose 1999; 2001), as they formed on what is essentially the hinge zone between uplifting and subsiding areas. Furthermore, absolute dating techniques for this period are associated with large margins of error and understanding the character of each of the interglacials is complex (Preece and Parfitt 2001; 2012). It can therefore be difficult to place sites confidently within specific interglacial periods. The faunal turnover throughout the period, despite not existing as formalised MAZs, is a useful tool for clarifying this issue and is shown in Figure 2.5.

Recent research using oxygen and stable isotope carbonates from these deposits has shown that sites such as Pakefield and West Runton (both MIS 19/17 [Parfitt *et al.* 2005; Stuart and Lister 2010]), formed under climates either the same as or much warmer than today's (Candy *et al.* 2011). Moreover, recent work by Candy and McClymont (2013) demonstrates that in the mid-latitude North Atlantic (40-56°N), none of the interglacial periods from MIS 19-13 were subjected to the 'global' (Lang and Wolff 2010) pattern of cooler interglacials. Nevertheless, the cooling that would have affected the surrounding oceans, leading to an increased temperature gradient between the mid-latitudes and the northern latitudes, could have affected other aspects of interglacial climates such as precipitation and seasonality. So whilst temperatures of these early Middle Pleistocene interglacial periods would have been similar to those of the proceeding marine-isotope stages, and to the Holocene, the configuration of the environments may have been significantly different, compounding the need to investigate them directly.

Text Box 4: Cromer Forest-bed Formation

Outcropping along the East Anglian coastline (Figure 1), the deposits of the Cromer Forest-bed Formation (CFbF) - laid down in a combination of marine (Wroxham Crag), freshwater and estuarine environments - form one of the most laterally extensive deposits in Britain. They provide a rich palaeontological, palaeoenvironmental and archaeological record of the Early and early Middle Pleistocene, in an array of climates both warmer and colder than the present (Preece and Parfitt 2012). Arguably the most comprehensive, classic work on the CFbF during the 19th century was carried out by Clement Reid (1882, 1890), who split the succession at the stage type-site of West Runton into three units, an Upper and Lower Freshwater bed with an intervening 'Forest bed' (estuarine deposit) from which he claims most of the mammalian remains are recovered (1882, 22).

Noting the difficulties involved with accessing and studying these seasonally elusive coastal deposits (1882, 22), Reid speaks of his and a colleague, Mr Newton's, knowledge of the beds as a "gradual growth" (1890, 148) with much still being debated. The changes in our understanding of this site that have occurred since the time of Reid demonstrate how right he was. It is now agreed (after West 1980) that the Upper Freshwater bed is actually composite in age, and consists of a lower layer of marls, considered late Beestonian (~1.78-0.78Ma), and overlying organic sediments, representing an early temperate environment of the Cromerian (~0.78-0.48Ma). These sediments have been redefined as the West Runton Freshwater Bed ([WRFB] West 1980; Preece and Parfitt 2000) and are the only part of the sequence at West Runton that are considered Cromerian in age (The Cromerian Complex being the period of time broadly synonymous with the early Middle Pleistocene: 0.78-0.48Ma).

Reid's dedication to the recording and analysis of the fauna and flora of these deposits led him to the conclusion that there had been some fluctuations in climate as well as sea level throughout its formation (Preece and Parfitt 2012). However, it was not until Richard West began applying pollen analysis to the task of disentangling the biostratigraphy of these deposits throughout the 1960s that the true complexity and time-depth of the CFbF began to emerge. It became clear that there was more than one temperate period represented, as well as several cold periods. West began to work on defining a stratigraphical nomenclature of the period which he published in his 1980 monograph. This work defined two Formations, the Norwich Crag Formation and the younger Cromer Forest-bed Formation. The Pastonian and Beestonian were the names assigned to the temperate and cold stages that pre-date the Cromerian and the sequence was defined as follows:

- Norwich Crag:
    - Pre-Pastonian a (substage) *Marine*
- Cromer Forest-bed Formation:
    - Pre-Pastonian b, c, d (substages) *Fluvial*
    - Pastonian (temperate) *mostly marine some freshwater*
    - Beestonian (cold)
    - Cromerian (temperate)
    - Early Anglian stage (MIS 12)

Significant hiatuses were identified in the CFbF record through a series of unconformities and erosional breaks, indicating that it is by no means continuous (Preece and Parfitt 2012). There are thought to be significant breaks both within and before the pre-Pastonian, between the Pastonian and Beestonian, within the Beestonian and between the Pastonian and Cromerian. These breaks have been further demonstrated by comparison with the Netherlands sequence which indicates that the Pastonian is Early Pleistocene (through correlation with the later part of the Dutch Tiglian on the basis of small mammal evidence) and separated from the Cromerian by an interval of time represented in the Netherlands by the Menapian, Bavelian, Eburonian and Waalian stages (Gibbard et al 1991).

Text Box 4: Cromer Forest-bed Formation

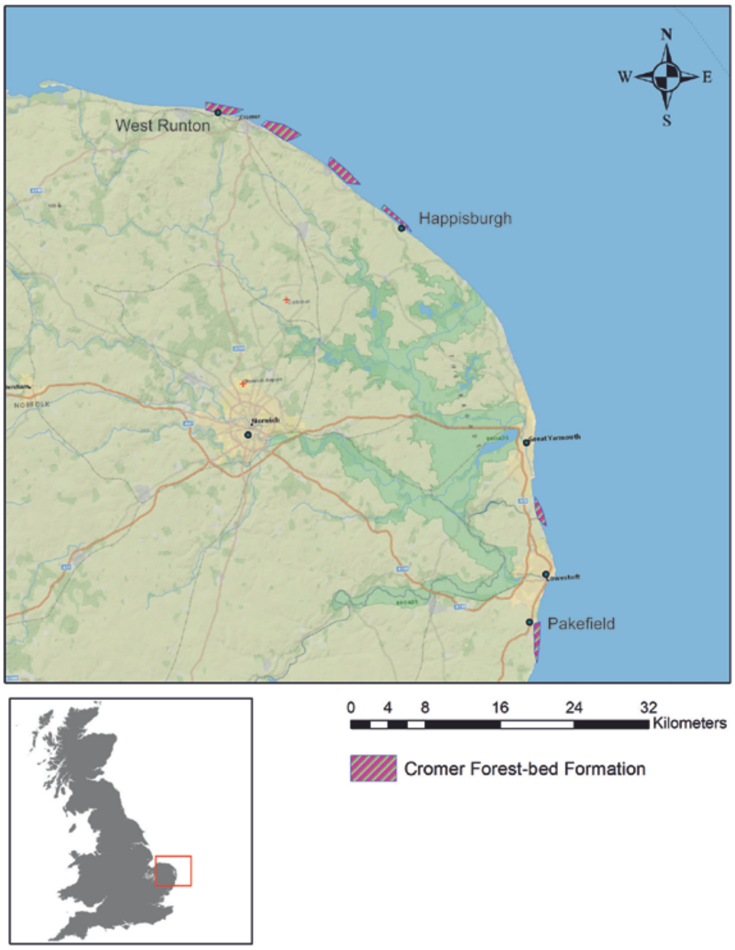

Figure 1 CFbF outcropping locations

Recent work by Rose et al. (2001) has added to this picture by defining a Wroxham Crag formation, which encompasses marine aspects of the CFbF. Essentially this divides the deposits of the CFbF into fluviatile or marine environments (ie. regressive / transgressive) and the subdivisions of its lithologies aid correlation of the exposures with other contemporary environmental systems such as river systems (see Section 2.1.3).

Despite West's work being pioneering and extremely thorough, some aspects have since been called into question. The most significant, for this work at least, being the conclusion that all of the early Middle Pleistocene interglacial sediments (those post-dating the Bruhnes-Matuyama boundary and pre-dating the Anglian glaciation) could be grouped into one interglacial stage, the Cromerian.
It is now thought that the Cromerian is made up of at least 5 stages/sub-stages (Preece and Parfitt 2000, 2012). These distinctions are drawn through analysis of mollusc, pollen and vertebrate evidence which show significant differences and patterning within and between the assemblages. The AAR work of Penkman (2005; 2010; Penkman et al. 2007; 2011) has gone a long way to resolving these issues but, due to a lack of absolute dating control, there are still issues assigning them to specific MI stages (see Preece and Parfitt 2012 for a full review of the arguments).

The dispersals of early hominins into North West Europe are therefore set within the context of interglacial cycles that warm and cool to extremes similar to those of the proceeding periods, and with lithic technologies associated with both extremes (eg. Parfitt *et al.* 2005; Ashton *et al.* 2008a; Parfitt *et al.* 2010). The major difference to these environments and landscapes was the configuration of the southern North Sea (Section 2.1) and what this means for the archaeological record. With the majority of early Middle Pleistocene sites situated in or towards the lower reaches of East Anglian rivers (specifically the Bytham River [Hosfield 2011]), this raises the issue of the importance of the submerged record for providing missing aspects of hominin interaction with lower-lying, potentially non-analogous environments.

In terms of faunal species, no formal MAZ exists for this period, as assigning specific sites to specific periods within the early Middle Pleistocene is still complex and difficult. Figure 2.5, however, shows species that have been demonstrated to exist throughout this period as well as the preceding Early Pleistocene.

2.3.1.2 The archaeological picture

The early Middle Pleistocene archaeological picture of Britain could arguably be split into two categories: first, the much earlier additions of Happisburgh 3 and Pakefield falling into that of the Early – early Middle Pleistocene forays north, and, secondly, the sites of MIS 13, falling into the traditional Lower Palaeolithic category (Figure 2.6). Both groups (if we follow the traditional glacial stratigraphy model, [e.g. Preece *et al.* 2009] have strikingly different patterns: the earlier picture of a few ephemeral, small assemblages of simple cores and flakes (Text Box 2; Parfitt *et al.* 2005; 2010), appearing almost unanimously with the earliest incursions of early hominins into new territories (Pettit and White 2012), and this contrasted with increasing site numbers within MIS 13 (Figure 2.6) and the emergence of handaxe technology across (most of) Europe (i.e. the Lower Palaeolithic [Roebroeks 2006; Scott and Gilbert 2009]).

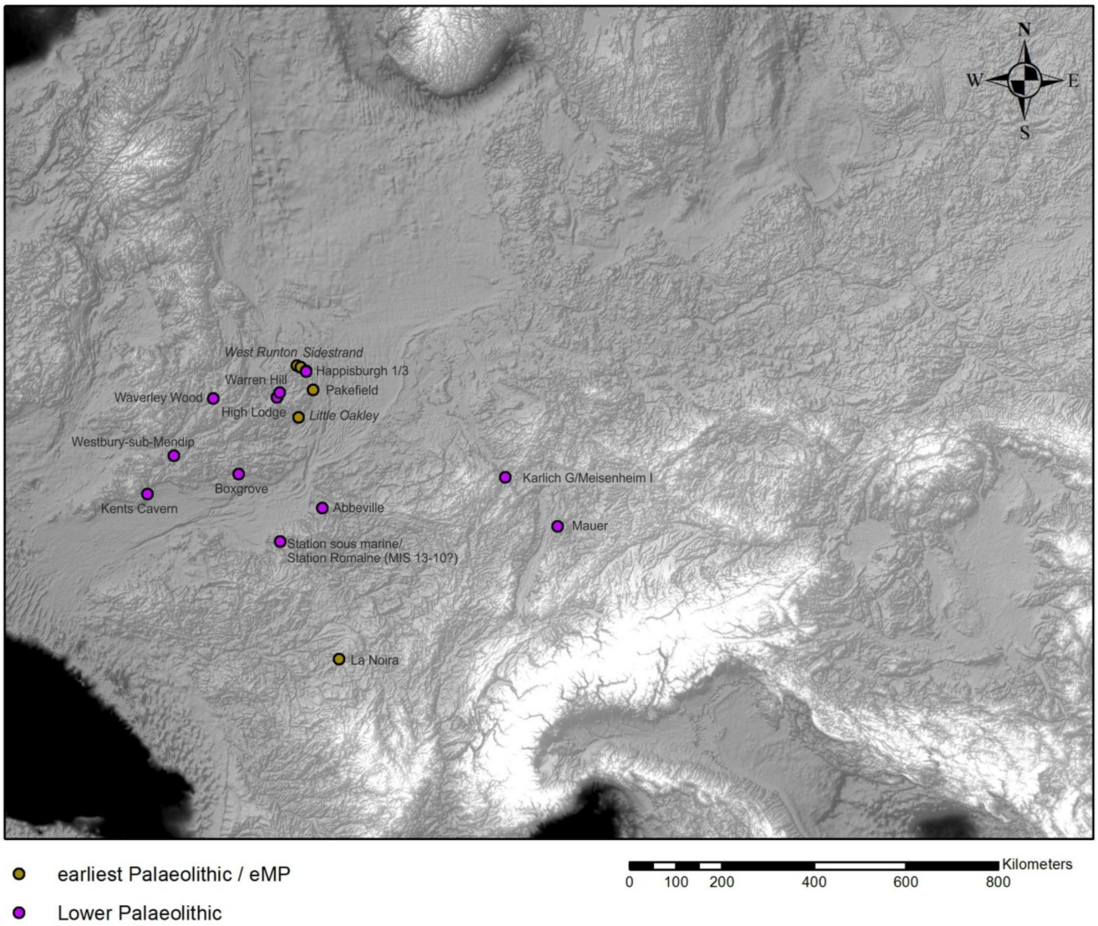

Figure 2.6 Earliest Palaeolithic sites (pre-MIS 13) of North West Europe, shown with those of MIS 13. Sites in italics are purely palaeoenvironmental.

If we assess the evidence from British early Middle Pleistocene sites we can more easily interpret the nature of these occupation episodes. Were they occasional forays north or repeated visits? The number of these sites has increased dramatically in recent years, and this has forced many who previously subscribed to a 'short chronology' of Europe (one where hominins did not enter this geographical area until after 500ka) to reconsider (Dennel 1983; Roebroeks and van Kolfschoten 1994;Dennel and Roebroeks 1996; Roebroeks 1996). Before even the discovery of the British sites, the Sierra de Atapuerca (Spain [Carbonell *et al.* 1995; Bermudez de Castro *et al.* 2004; Pares *et al.* 2006]), showed lithics and hominin remains in layer TD6 at the Trinchera Dolina site stratified well below the Bruhnes-Mutayama boundary (0.78ka). This made it clear that the earlier model of European occupation needed to be modified. The warmer climates of the Mediterranean region leant themselves easily to this modification, but, the sites of Pakefield and then Happisburgh 3 within the CFbF of East Anglia (Parfitt et al 2005, 2010) were more difficult to reconcile. Providing evidence for occupation at approximately 700kya and 814 – 970kya (MIS 17/19 or MIS 21/25 [Parfitt et al 2005; 2010]), in warm interglacial and boreal conditions respectively, and far north of the contemporary occupation seen in southern Europe, they represent occupation in environments unprecedented for hominins of this period. Further work over recent years has to some extent solidified the integrity of this 'long chronology', with occupation of Sima del Elephante, Atapuerca, at 1.1-1.2Ma (Carbonell *et al.* 2008), Orce, Spain, at 1.4Ma and Pirro Nord, Italy, at 1.3-1.7Ma (Arzarello *et al.* 2007). But questions remain about the reliability of these early European dates (Dennel and Roebroeks 1996; Roebroeks 2001; Villa 2001; Antón and Swisher 2004; Muttoni *et al.* 2013), especially after the re-assignment of Ceprano to ~0.45Ma (Muttoni *et al.* 2009) after initial dates of ~0.78Ma (Manzi 2004).

Whether these sites are quite as early as believed (for example, Muttoni *et al.* 2013 would place them at between 0.78 and 0.99Ma, based on the combination of date ranges and faunal zonations), this is still a significant modification of the short chronology. The interesting implications that this has for early hominin capabilities facilitate a new way of thinking about these patterns: do they indicate limitations to hominins' abilities to cope with the climatic conditions associated with being at these latitudes for prolonged periods? Questions are therefore raised about how and why they were here. Do these periods of occupation demonstrate adaptations to these environments, especially those of HSB3, or are we seeing the limits of occasional migrations north, facilitated by familiar habitats or unrecognised climatic pulses and resulting in localised extinctions? On the other hand, with Pleistocene coastlines predominantly now submerged, are we still simply missing the evidence?

Dispersals from areas of southern Europe along the Atlantic margin, utilising lower reaches of rivers and coastal resources, has been proposed by Cohen *et al.* (2012), and relies on an oceanic effect creating buffered 'refugia'-style areas, where populations could survive year-round (also see Candy and McClymont 2013). Despite the frustrating scarcity for the evidence of such sites, or of adaptations to the winter temperatures, which, oceanic effect or not, would still have been regularly below zero (Hosfield 2011), the evidence that does exist suggests either coastal or fluvial environments along the edge of Western Europe (e.g. Parfitt et al 2005; 2010; Cohen *et al.* 2012). Given the loss of the great majority of these coastal areas since the last transgression, this emphasises again the need to investigate the areas now submerged.

Britain, at the most North Westerly point of the European continent, has a well-documented yet complex record of occupation (MacDonald *et al.* 2012), with much dating of sites relying on stratigraphic relationships with complicated glacial stratigraphy (Section 2.2). Understanding the ecological preferences, tolerances and adaptations of these early hominins may help to pin down areas where we could focus our investigations, and an appreciation of their associated environments - in the areas that we assume they are migrating from - should provide the framework for this understanding. Given the dates and relative abundance of sites in southern and south-eastern Europe during the Early – early Middle Pleistocene, it seems likely that these areas provided at least one source for the populations migrating northwards. It has been pointed out by Ashton and Lewis (2012) that few of these sites are associated with good environmental evidence, but what does exist points towards open grasslands with deciduous forests and moderate temperatures (Gabunia *et al.* 2000; Arzarello *et al.* 2007; Scott *et al.* 2007; Blain *et al.* 2008; Messager *et al.* 2010; Rodrigues *et al.* 2009; 2010). Again, Cohen *et al.*'s (2012) Atlantic coastal hypothesis offers a potential clue to how hominins then survived in the harsher, seasonal northerly environments, but the evidence is still sparse. Nevertheless, these ideas provide us with a point to start thinking about how and why hominins made it so far north so early, where we might be likely to locate such early sites, and what we should be doing to maximise the archaeological potential of the extant record.

2.3.1.3 Summary

Given the connected, terrestrial nature of the geography of the southern North Sea during this pre-breach period, the potential contained in the offshore resource could help us to further address some of these questions, particularly about the ecologies, migrations and exploitation patterns of early hominins. These issues are central to our understanding of hominins throughout the Palaeolithic and provide insight into preferences and behaviour, which will feed back into research on patterns of movement throughout the period.

The acceptance or consideration of this framework for the early occupation of North West Europe, one that presents a rather discontinuous picture facilitated by the use of coastal areas, highlights the importance of investigating submerged deposits.

2.3.2 Lower Palaeolithic (MIS 13 – MIS 9, 533 – 300ka)

The archaeological picture of MIS 13 is significantly different from that of the earlier, core and flake-type archaeology of Happisburgh 3 and Pakefield, the environments of which have been discussed above (also see Text Box 2). Argued to reflect the arrival of a new species, *Homo heidelbergensis* (Roberts and Parfitt 1999; Roebroeks 2006; Ashton and Lewis 2012), this shift in the record marks the start of the traditional 'Lower Palaeolithic' of Britain, which as defined for this work encompasses five marine isotope stages, three interglacial (MIS 13, 11, 9) and two glacial (MIS 12, 10), and covers a period of approximately 230Kyrs (524 – 300Ka). The Elsterian (MIS 12) is here accepted as the first lowland glaciation of Britain and the most extreme, reaching as far south as London (Figure 4.15 [Bridgland 1994]), and lasting 47Kyrs.

The production of Acheulean handaxes in this period (bifacially worked and shaped larger cutting tools, with a [nearly always] cutting edge all the way around, variable in size and shape [see Roe 1968; Goren-Inbar and Sharon 2006; McNabb 2007; Cole 2011], and remaining approximately static from c. 1.7mya BP – 200kya BP [Clark 1994; Gamble 1999; Santonja and Villa 2006]) marks the start of the traditional Lower Palaeolithic in Britain. We see their first appearance in Britain at approximately MIS 13 (Section 2.3.2.2), with their gradual demise from MIS 9 representing the transition into the Early Middle Palaeolithic.

Their distribution throughout North West Europe is patchy, with an apparent absence in Belgium and the Netherlands, suggested to be a result of the extensive ice sheets which later covered this area (Vos and Kidden 2005). This also makes it very difficult to assess what the absence of evidence really means (Figures 2.6 and 2.7). Their archaeological distribution will be discussed in more detail in Section 2.3.2.2, after a discussion of their contemporary environments.

2.3.2.1 Environmental context

The severity of the Elsterian glaciation (Figures 1.2 & 2.2) caused a dramatic reconfiguration of the peninsula of North West Europe, both in terms of the previously-discussed Weald Artois ridge (Section 2.1, Figure 2.2) but also in terms of the landscape, with much of the chalk-rich uplands being significantly eroded (Lewis 1992; Clayton 2000; Busschers *et al.* 2008; Toucanne *et al.* 2009; Hosfield 2011; Hijma *et al.* 2012) and potentially eroding, or altering some previous archaeological signals (e.g. High Lodge [Lewis 1998]). Reconfiguration of this magnitude will have had implications for hominin, as well as floral and faunal, dispersals, but it is not yet certain at which point Britain was totally cut off; its immediate effect is likely to have been limited. Marked fluctuations are seen in the record, both locally within sedimentary sequences (e.g. Ashton *et al.* 2008a) as well in big-picture ice core data (e.g. Bassinot *et al.* 1994). Although on timescales not necessarily discernible through modern dating techniques, these would have had a dramatic effect on the environment, landscape (especially through changing sea levels and availability of landmass) and its contemporary inhabitants.

Given the continued subsidence of the North Sea basin throughout the Pleistocene (Busschers *et al.* 2008) and the level of deposits at sites such as Clacton and Swanscombe (Bridgland *et al.* 1999; Ashton *et al.* 2008b), it appears that only a small drop in relative sea levels would have been enough to expose the contemporary shallow sea-floor (Ashton *et al.* 2011). This sea-floor becoming increasingly less shallow through time and leading to ever more periods of isolation from the continent as the Pleistocene progressed.

The association of *Homo heidelbergensis* (Roberts and Parfitt 1998), or early Neanderthals ([from c.MIS 11] Stringer 2012; McNabb 2014) with the increase in both number and density of sites from MIS 13 – MIS 11/9 (Figures 2.6 and 2.7), occurs in an array of environmental conditions. From the cooler, boreal-type environments of Happisburgh 1 (MIS 13 [Ashton *et al.* 2008a), Boxgrove (MIS 13/12 [Roberts and Parfitt 1998]), and Cagny la Garenne (MIS 13/12 [Bridgland *et al.* 2006; Antoine *et al.* 2010]) to the more traditionally interglacial sites of Beeches Pit (MIS 11 [Wymer 1985; Preece *et al.* 2000; 2006; Gowlett *et al.* 2005; Gowlett 2006]), Swanscombe (MIS 11 [Wenban-Smith *et al.* 2001]) and Bilzingsleben II (MIS 11/9 [Mania 1995; Mania and Mania 2005]), the sites are almost all situated within river valleys or, occasionally (as at Hoxne [West 1956; Ashton *et al.* 2008b; Ashton and Lewis 2012]), by freshwater lakes. Presumably this is due to the resources, ease of movement and visibility afforded by these areas (Ashton *et al.* 2006; 2008b; Brown *et al.* 2013), although the preservation and research biases (i.e. modern gravel extraction) of these environments may also have at least some role to play. The ability to survive at these latitudes and in a wide range of conditions, including harsher conditions (with sites such as High Lodge and Happisburgh 1 indicating winter temperatures several degrees below freezing [Hosfield 2011]), at such relatively increased densities implies that these hominins had developed or intensified their means of coping, be it clothing, shelter or the controlled use of fire (e.g. Beeches Pit [Gowlett *et al.* 2005]).

MIS 11 and MIS 9 have remarkably similar palynological signatures (e.g. Cudmore Grove [Roe *et al.* 2009], Hoxne [West 1956, Ashton *et al.* 2008b; Ashton and Lewis 2012]), often being distinguished on the basis of mammalian assemblages (Schreve 2001; 2004), lithostratigtraphy and, more recently, OSL dating (e.g. Briant *et al.* 2012). Isotopically, MIS 11 and MIS 9 both have rapid warming at the start, but MIS 9 has an isotopic pattern similar to other interglacials (e.g. MIS 5) showing a series of warm and cold periods: MIS 9e, 9c and 9a are warmer periods and MIS 9b and 9d cooler, with each warm stage being isotopically cooler than the last (Bassinot *et al.* 1994; Hopkinson 2007; Currant and Jacobi 2011). The pollen isotopic signature for MIS 11 also demonstrates warm peaks, but only two are consistently recognised: MIS 11c and MIS 11a (Ashton *et al.* 2008b).

2.3.2.2 Archaeological picture

Changing patterns of glacio-isostatic uplift throughout different Lower Palaeolithic glacial-interglacial stages point to changing patterns of connection and isolation (Roe 2001; Preece and Penkman 2005; Ashton *et al.* 2008b; Ashton *et al.* 2011). Ashton and Lewis (2002; Ashton *et al.* 2011), looking at artefact densities through time, suggest that Britain's separation was not complete until right before the Eemian interglacial (MIS 5e), a theory supported by the biostratigraphical work of Meijer and Preece (1995), Currant and Jacobi (2011) and more recently bathymetric and sedimentological research (Gupta *et al.* 2007; Toucanne *et al.* 2009a). They argue that the Lower Palaeolithic has a rich signal relative to both earlier and later phases, despite changing patterns of landscape use and lithic technologies (e.g. White *et al.* 2006; Scott 2006; Scott *et al.* 2011). Having been retested using several different regions and lithic groupings (Ashton and Hosfield 2010; Ashton *et al.* 2011), the observed patterns are likely to be due in part to the changing patterns of isolation. This was driven by a combination of the breaching of the Weald-Artois ridge, with the interplay between the subsiding southern North Sea basin and changing sea levels (Busschers *et al.* 2008). Movement across, and occupation of, the southern North Sea would therefore have been variably possible for significant parts of the Lower Palaeolithic.

MIS 13 (533 – 478ka)

The British archaeological signature of MIS 13 is marked by the apparently sudden production of Acheulean handaxe technology at Bytham river sites such as Happisburgh 1 (Figure 2.6, Ashton *et al.* 2008b), High Lodge (Ashton *et al.* 1992), Waverley Wood (Shotton *et al.* 2003, although see Preece *et al.* 2009 for potential MIS 15 date through AAR dating), and Warren Hill (Roe 1968; Wymer 1985; Wymer *et al.* 1991; but cf. Lee *et al.* 2004; Gibbard *et al.* 2009), as well as the (non-Bytham) site of Boxgrove (Roberts and Parfit 1999). The chronological debate over these sites is by no means resolved and disagreement still exists surrounding, for example, whether the archaeological gravels are fluvial or glacial in origin (e.g.

Warren Hill [Gibbard *et al.* 2009]), whether the traditional Biostratigraphic Model is still followed (Section 2.2) and how the lowest Bytham terraces are interpreted (e.g. Bridgland *et al.* 1995; Lewis 1998; Preece and Parfitt 2008 for hypotheses regarding multiple MIS 12 terraces in the Bytham system in a similar way to the Thames terraces [Bridgland 1994]). This is by no means an exhaustive list of sites, with several such as Brandon and Mildenhall, both in East Anglia, of uncertain chronology (for a full discussion see Hosfield [2011] and references therein).

The Solent River and its tributaries contain artefacts, but there is doubt as to the dating of these terraces. The archaeology is generally considered to be restricted to MIS 13, on the basis of OSL dates on lower terrace sequences (Briant *et al.* 2009; Briant and Schwenninger 2009). Furthermore, with regard to the pre-diversion Thames, there are strikingly few examples of lithics from any of these terraces, with only find spots, a few flakes and a handaxe, none of uncontroversial provenance (Wymer 1999; Hosfield 2011).

North West European sites with Acheulean technology can be found in France in the area of Abbeville (Tuffreau and Antoine 1995; Tuffreau 2001), with the sites of Saint Acheul (MIS 12: 403±73 ka) and Cagny la Garenne (MIS 12: 443±53 and 448±68 ka). More recently, claims have been made for a handaxe assemblage from the terraces of the Cher River (La Noira, Middle Loire Basin), with ESR dates of 665±55 ka; (MIS 15/17 [Moncel *et al.* 2013]), significantly older than those from Britain. Potentially pushing the European Acheulean back even further are the Spanish sites of Solana del Zamborino (750-770ka) and Estrecho del Quípar (c 900 ka [Scott and Gibert, 2009]), although at present the especially early date seems anomalous, the discovery and dating of La Noira is potentially supportive (McNabb 2013). Are we missing these early examples of Acheulean technology in Britain because they have not been preserved or because we have dated them wrongly? On the other hand, are the hominins using this technology simply not present?

The earlier appearance of handaxe technology on the Continent (e.g. Tuffreau et al 2008; Barsky and de Lumley 2010; Jimenez-arenas *et al.* 2011 ; Moncel *et al.* 2013) may reflect the movement of hominins using this toolkit and appear in younger settings than the initial appearance of core and flake assemblages in these regions. There is still of course debate whether these handaxe makers reflect the movement of a new species such as *Homo antecessor* to *Homo heidelbergensis*, bringing with them a new lithic repertoire (Moncel *et al.* 2013). The paucity of a reliable fossil record makes this hard to clarify, with the much-debated Atapuerca sites having by far the richest record (see Arsuaga 1997; Bermudez de Castro *et al.* 1997; 1999; 2003; Carbonelle *et al.* 2008; Stringer 1993; 2012). With recent mitochondrial evidence pointing to the emergence of early Neanderthals at 538-315 kya, and hominins at Swanscombe now re-assigned to this species (Stringer 2012; McNabb 2013), early Neanderthals must also have played a part in the emergence and evolution of the Acheulean tradition.

Northern German sites allow an interesting comparison, with the sites of Miesenheim I and Kärlich G both assigned an early Middle Pleistocene date of MIS 13/15 (van Kolfschoten and Turner 1996; Turner 2000; Bosinski 2008; Parfitt and Preece 2012). Both of these sites are characterised by flake technology with apparently no bifacial components. Bifacial technology is clearly being used in contemporary sites elsewhere in Europe, so this raises two questions: first, does the lack of bifacial technology at the German sites simply represent a different response to a situation, on the basis that handaxes were not needed and so were not made, raw material constraints precluded their manufacture, or that they were brought and taken away? Or, secondly, does it represent occupation by different groups or 'cultures' of hominins from different regions using different knapping techniques? A similar argument has dominated British archaeological discussion of the succeeding interglacial, but it is by no means resolved.

MIS 11 (424-374ka)

The MIS 11 (Holstenian) interglacial is represented by several sites in a range of environments such as Clacton, Swanscombe, Hoxne, Barnham and Beeches Pit (Figure 2.7). Ranging from cold, boreal environments (although with warm summer temperatures) at Hoxne (Ashton *et al.* 2008b), to fully interglacial, closed forest environments at Beeches Pit (Gowlett *et al.* 2005; Preece *et al.* 2006), these sites attest to hominin occupation throughout the interglacial. They are generally associated with fluvial environments, leading Ashton *et al.* (2006) as well as, more recently, Brown and colleagues (2013) to suggest that these were hominins' preferred locations for nutrients and resources, as well as movement, with the paucity of environmental information associated with interfluve environments making these sites difficult to tie in. The Holstenian sites have also yielded some of our earliest evidence in North West Europe for wood working (the Clacton spear [Warren 1911]) and the use of fire (Beeches Pit [Gowlett *et al.* 2005; Preece *et al.* 2006]). The Schöningen throwing spears (Thieme 1997; Thieme 2007; van Kolfschoten 2013) had been assigned to the Holstenian period, but recent work (van Asperen 2012; Schreve 2012; van Kolfschoten 2013) has indicated that, although archaeological sites from the Holstenian do exist at Schöningen, the spears are more likely to derive from MIS 9.

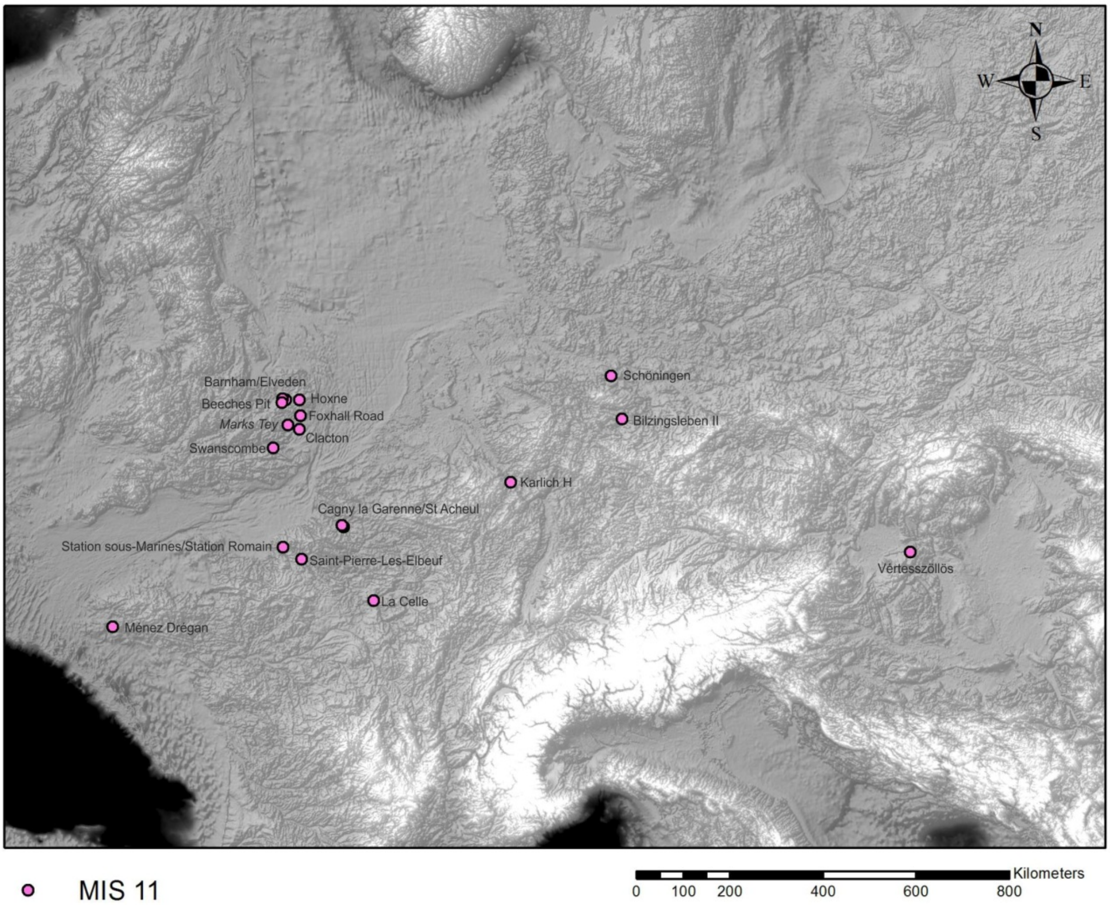

Figure 2.7 MIS 11 sites, palaeoenvironmental sites in italics

Patterning in the archaeological signatures at these sites has led to the long-running 'Clactonian' debate (Wenban-Smith 1998; White 2000, but see McNabb

2007 for a full discussion). This has to do with the occurrence of assemblages without evidence for any handaxe manufacture (Clactonian) at the same time, broadly speaking, as Acheulean, handaxe assemblages. The question is whether this is a real picture: two assemblage types produced by different hominin cultures, with Clactonians during the initial stages of the interglacial (also potentially at the start of MIS 9 at Little Thurrock [Wymer 1957; Snelling 1964; Bridgland and Harding 1993; McNabb 2007]), followed by an Acheulean replacement (e.g. Swanscombe [White 2000 based on Bridgland 1994; Schreve 1997, 2001]); or two distinct assemblage types produced perhaps as a response to different conditions, by indeterminate hominins. With sites such as Barnham producing evidence of Clactonian and Acheulean industries with at least geological contemporaneity and within the same strata (Cobble band [Ashton *et al.* 2006]), arguments relying on different environmental conditions have at least a shadow of doubt cast over them. Such close proximity is also difficult to imagine from the point of view of territory, but geological timescales are of course very different from human timescales.

Given the implications for the occupation of north west Europe being attributable to movement from the continent, the outcome of the Clactonian problem may allow us to recognise different hominin cultures within what is probably the same species - *Homo heidelbergensis* (e.g. Boxgrove, Mauer) or early Neanderthals (e.g. Swanscombe) - throughout different areas of Europe (White and Screve 2000). With Eastern and Central European sites such as Vértesszőlős (McNabb and Fluck 2007; Fluck 2010) and Bilzingsleben (Mania and Mania 2005) being devoid of handaxe technology, compared with handaxe yielding sites in Western and Southern Europe (e.g. Cagny la Garenne [Lamotte and Tuffreau 2001], Saint-Pierre-lès-Elbeuf, lower Seine valley [Cliquet *et al.* 2009], this interpretation does seem attractive. This is especially the case when we take into account the recent evidence pointing to complex species interactions and existence throughout Asia, Africa and Europe throughout the Pleistocene (e.g. Stringer 2012: Denisovans, Floresiensis; Lordkipanidze *et al.* 2006). Work by Dennell *et al.* (2011), which paints a picture of waves of hominin movement, sits well with this interpretation, as it expects differing 'cultural' elements associated with multiple phases of abandonment and re-colonisation under varying climatic regimes.

However, as attractive as identifying movements of Lower Palaeolithic cultures may seem, it is important to point out that the chronologies of Clactonian and Acheulean industries are based on environmental data and are therefore quite temporally broad. There are only a small number of sites to work with and, given how hard it is to ascertain the functionality of lithic technologies with any certainly, is not the assumption that they were used by the same groups, possibly at different times but for different reasons, the most elegantly parsimonious?

These arguments are not resolved and we still do not know what the Clactonian means for the Palaeolithic. The discovery of more sites and a broader understanding of hominins within their varied ecologies from areas now submerged may help to elucidate these issues. Moreover, archaeology from late in MIS 12 or early in the interglacial - when sea levels were still rising – may be undertaken in areas that are now submerged, and these areas may well shed light on the earlier movements of the hominins.

MIS 9 (337-300ka)

After several hundred thousand years of handaxe-dominated assemblages, the latter stages of MIS 9 sees the emergence of a different type of stone tool technology with the development of Simple Prepared Cores (SPCs) alongside the use of handaxes (Bolton 2010; Scott 2011). Appearing in the literature under an array of terms, for example proto-Levallois, pseudo-Levallois (from here on: Simple Prepared Cores [SPCs] after Bolton 2010), this appears essentially (although not without on-going debate) to represent the development *in situ* of a new way of thinking about lithic manufacture. It is seen at sites such as Botany Gravel, Purfleet (MIS 9 [Wymer 1968; 1985; Roe 1981; Bridgland *et al.* 2013]) and Cuxton (?early MIS 8 [Bolton 2010]) (Figure 2.8). SPCs are defined by their clear use of hierarchical surfaces, striking versus flaking and parallel removals to the plane of intersection, but in contrast with later 'developed' prepared core technology (i.e. Levallois), SPCs do not necessarily show maintenance of distal and lateral convexities and there is minimal preparation of surfaces (White and Ashton 2003; Bolton 2010).

An earlier 'proto' stage has been seen as the precursor to Levallois, the emergence of which defines the start of the Early Middle Palaeolithic. This argues against the hypothesis that the technology was brought into Europe with the spread of a new hominin species (e.g. *Homo helmei* [Lahr and Foley 1997]). In fact, not only do we see a clear development *in situ* of the technique (Moncel and Combier 1992; Scott and Ashton 2011; Moncel *et al.* 2012; Picin *et al.* 2013), but in areas of the world with a paucity of handaxe assemblages, Levallois never fully develops (Gao and Norton 2002). White and Ashton (2003) have argued that Levallois represents the principles of façonnage exapted to those of débitage: in other words Levallois technology took the principles behind the shaping of a core of material to produce a final tool (the handaxe) and applied this to the principles of flake production, both techniques fully developed within Lower Palaeolithic handaxe technology. Levallois therefore seems to represent a new way of thinking about the use of material, and is perhaps a response by hominins to changing exploitation of their surroundings.

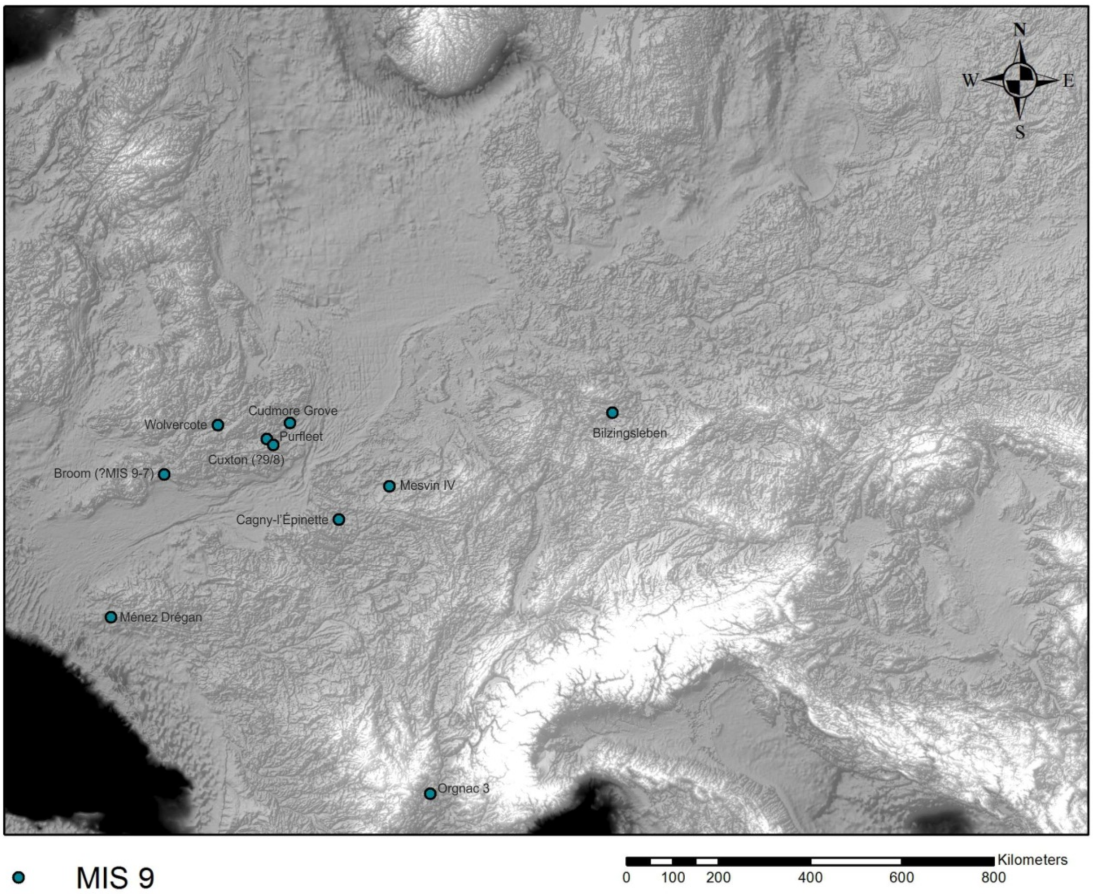

Figure 2.8 MIS 9 sites in Britain and North West Europe

The appearance of SPCs on the continent occurs earlier than MIS 9, at sites such as Cagny la Garenne (MIS 12/11), where there is argued to be a clear conceptual link between the manufacture of handaxes and that of Levallois (Tuffreau and Antoine 1995). This adds further weight to the argument of development *in situ*. The much earlier appearance in France may reflect a geographically and temporally diachronic pattern of development, perhaps related to the ease of movement through these areas at this time. However, the haphazard nature of the study of this lithic phenomenon in Britain as well as the continent, reflected by the plethora of terms adopted for what is essentially the same thing, may be confusing the picture. New research addressing this issue should clarify the situation (Bolton pers. comm.), with re-analysis of lithic assemblages in Britain and North West

Europe potentially identifying SPCs at ever earlier sites and clarifying their relationship with both the Acheulean and Levallois traditions.

2.3.2.3 Summary

During the Lower Palaeolithic Britain and North West Europe were relatively intensively occupied, but this was not by any means continuous. The contention that occupation of Britain occurred as a response to constantly expanding and contracting populations from more southerly, less climatically severe areas of Europe and the Near East (Dennell 2003), fits this occasional signal of occupation. The emergence of SPCs, apparently *in situ*, at approximately corresponding points throughout the continent and Britain further highlights this movement of hominins and reflects the peninsula status of Britain for at least some if not most of this time.

Analysis of lithic concentrations in the Thames valley, as well as more recent analysis of concentrations further west (Ashton and Lewis 2002; Ashton and Hosfield 2010; Ashton *et al.* 2011), imply a decline in populations throughout the Lower Palaeolithic, culminating in an absence from MIS 6 – late MIS 4/early MIS 3 (Section 2.3.3.3). The changing palaeogeography of the southern North Sea basin and consequent decrease in opportunities for access seem like a logical explanation for this.

How these patterns of occupation relate to changes in palaeogeography requires a greater understanding of the now-submerged deposits as well as their potential associated archaeology. With Britain at the edge of the hominin range throughout the Palaeolithic, are the expressions of occupation we are seeing merely the excursions of occasional hominin groups, increasingly hindered by palaeogeographic and climatic changes? Engagement with the record from the southern North Sea may help to clarify this, as well as provide records of associated (potentially non-analogous) ecological and environmental changes and how Lower Palaeolithic hominins were interacting with them.

2.3.3 Early Middle Palaeolithic (EMP, late MIS 9 - 6, c.300 – 191kya)

This section on the Early Middle Palaeolithic will concentrate on the picture from late MIS 9 – MIS 6, which encapsulates a period dominated by Levallois technology in association with a suite of Middle Palaeolithic behaviours such as changes in landscape use, hunting and curation of materials (Geneste 1989; Feblot-Augustins 1999; Gaudzinski 2006).

The advent of the persistent use of Levallois technology marks the start of the Early Middle Palaeolithic at approximately late MIS 9 until MIS 6 (325ka – 180ka [Gamble and Roebroeks 1999; White *et al.* 2006; Richter 2011]). Long thought of as the 'muddle in the middle', biostratigraphic (Schreve 1997; 2001) and chronostratigraphic (Penkman 2005; Briant *et al.* 2006) frameworks have now allowed these two previously unrecognised interglacials to be defined as distinct periods, together with a number of archaeological sites (e.g. Roe *et al.* 2009; Roe and Preece 2011; Scott 2011). Few hominin fossils exist for this period in Britain or North West Europe and so (aside from the Neanderthal dental evidence at Pontnewydd cave, Wales [Aldhouse-Green *et al.* 2012]), assigning sites to species is not possible. However, it would appear from later fossils as well as DNA (Stringer 2012) that we are dealing with Neanderthals, as seen at sites in northern Spain, such as those from Atapuerca (Bischoff *et al.* 2007; Stringer 1993; 2012).

2.3.3.1 Environmental context

The environments of the Early Middle Palaeolithic are characterised by two glacial phases, MIS 8 and MIS 6 and one interglacial, MIS 7, with the succession of phases often referred to as the Saalian Complex. For the whole of this succession of periods, containing only one interglacial, there is little information available about environments, especially for the severe glaciation of MIS 6. With little palaeoenvironmental evidence available for anything other than the early and later stages of MIS 7 (Pettit and White 2012), the majority of information for this period has been gleaned from the mammalian record (Schreve 2001; 2004; Pettit and White 2012).

MIS 8 was a long glaciation, lasting approximately 50kyrs, but it was less severe than others (Bassinot *et al.* 1994; Ehlers *et al.* 2004). Glaciation of Britain, although elusive, can now be demonstrated for areas of the Southern Bight, in the southern North Sea (Beets *et al.* 2005) and northwards of Lincolnshire (White *et al.* 2010; Graham et al. 2011). With two warming phases during MIS 8 and a longer warming period towards the end of the glaciation (Toucanne *et al.* 2009a), there are archaeological sites associated with the end of MIS 8, notably at Baker's Hole and Purfleet (Scott *et al.* 2010; Bridgland *et al.* 2013).

MIS 8 sees the first incursions of the 'mammoth steppe' environment, at Bakers Hole as well as continental sites such as Mesvin VI and Markleeberg (Gamble and Roebroeks 1999). Hominin adaptation to this has been argued to be reflected in the technological and hunting strategies adopted from the Middle Palaeolithic (Gaudzinski 2006; Scott 2012). Species such as *Coelodonta antiquitatis* (woolly rhino) and *Mammuthus primigenius* (woolly mammoth) make their first appearance in Britain within this glacial period (Schreve *et al.* 2002).

The interglacial of MIS 7 begins and ends with the usual vegetation succession, showing cooler and more open conditions moving into a more closed, wooded environment. However, global ice core records show that this interglacial is characterised by three warm peaks, MIS 7e, MIS 7c and MIS 7a, (with high sea levels but not to modern levels [Waelbroeck *et al.* 2002]) and two intervening cold peaks at MIS 7b and MIS 7d; d apparently far more severe, with sea levels dropping by ~85m compared to ~25m for MIS 7b.

Evidence from the Norton – Brighton raised beach deposits indicate marine transgression at points throughout MIS 7 (Bates et al 1997; 1998; 2000; 2003; 2010), with deposits at Norton Farm indicating that, in contrast with the abrupt climatic deterioration at the end of MIS 7(~180Ka), sea levels remained high for a time after glacial inception. This has potential implications for hominin movements as it shows that climatic deterioration is not automatically associated with lowered sea levels.

The faunal evidence, as shown in Figure 2.5, has elucidated the changing environments of MIS 7 further. The original interpretation of two warm phases separated by a cooler period was based on the identification of a mixture of wooded and open species. It was thought that there was a warmer, more wooded period first (Ponds Farm) followed by a cooler, more open phase (Sandy Lane) after the climatic deterioration. Although this holds true, it is clearly more complicated, with these MAZs being applicable to multiple stages of MIS 7. For example Ponds Farm could apply to MIS 7e and 7c [Candy and Schreve 2007]. In general, there are more species indicative of open, cooler environments (e.g. *Mammuthus primigenius* [woolly mammoth], *Equus ferus* [wild horse], *Stephanorhinus hemitoechus* [narrow nosed rhinoceros], *Coelodonta antiquitatis* [woolly rhinoceros] and *Megaloceros giganteus* [giant deer]; derived from 30 stratigraphic horizons from 22 archaeological and palaeontological sites). The smaller proportions of woodland species (such as *Palaeoloxodon antiquus* [straight tusked elephant] and *Ursus arctos* [brown bear]) demonstrate the mosaic of environments that would have existed as well as significant fluctuations in climate.

MIS 6 was a severe glaciation, with a warming event at the start (possibly comparable to MIS 7e) but subsequently descending into extreme glacial conditions (Dansgaard *et al.* 1993) with ice reaching as far south as the Midlands (Lowe and Walker 1997). Its ending was characterised by a two-stage deglaciation, with the Zeifen interstadial followed by the Kattegat Stadial before amelioration into the Eemian (Binka and Nitychoruk 2001).

2.3.3.2 Archaeological picture

Compared with the abundance of sites in the Lower Palaeolithic, Early Middle Palaeolithic occupation appears to be less intensive (Figure 2.8 – 2.9; Ashton and Lewis 2002; Ashton *et al.* 2011; cf. Scott 2012). Part of this picture of decline may be attributable to technological change, with Levallois and handaxe technologies not being directly interchangeable (see Scott 2006; White *et al.* 2006; Scott *et al.* 2010), but recent analyses of Levallois sites by Ashton *et al.* (2011) would suggest that the picture of decreasing populations may in fact be real. Undoubtedly, the difficulties of reaching Britain during high-sea-level periods will also have played a part in this apparent decline in populations, with evidence pointing to decreasing terrestrial connection or at times during MIS 7, possible isolation (Bates *et al.* 1997; 1998; 2000; 2003; 2010).

The environments of the Early Middle Palaeolithic appear to be more open than the wooded environments of previous interglacials (Guthrie 1990; Schreve 2001; 2004; Candy and Schreve 2007) and the widespread adoption of Levallois is often seen as an adaption to this. Although transport distances in Britain are not as significant as on the Continent (Scott 2011), this change in environmental structure would have meant a change to the faunal elements that hominins were exploiting (e.g. Sandy Lane, Pond Farm MAZs, Figure 2.5), with more open herd species (e.g. *Stephanorhinus kirchbergensis* [Merk's rhinoceros] and *Equus ferus* [wold horse]), meaning a more mobile, potentially unpredictable hunting pattern. In this case, the curation of lithic technology could lead to a reduced discard rate, with removals occurring only when necessary, resulting in a reduced archaeological visibility (White *et al.* 2006; Scott 2011).

MIS 8 (300-243ka)

MIS 8 sees archaeological sites in North West Europe using a range of technologies in cool and open conditions characterised by palynology as well as species such as *Coelodonta antiquitatis* (woolly rhino) and *Equus ferus* (Horse) (e.g. Mesvin IV, La Salouel [Van Neer 1986; Ameloot-van der Hiejden *et al.* 1996; Scott and Ashton 2011; Pettit and White 2012]). In Britain, however, there are no sites until the end of this period (Figure 2.9). This demonstrates the speed at which recolonisation could take place and probably reflects the less severe nature of this glacial compared with those from earlier and later periods (Scott and Ashton 2011).

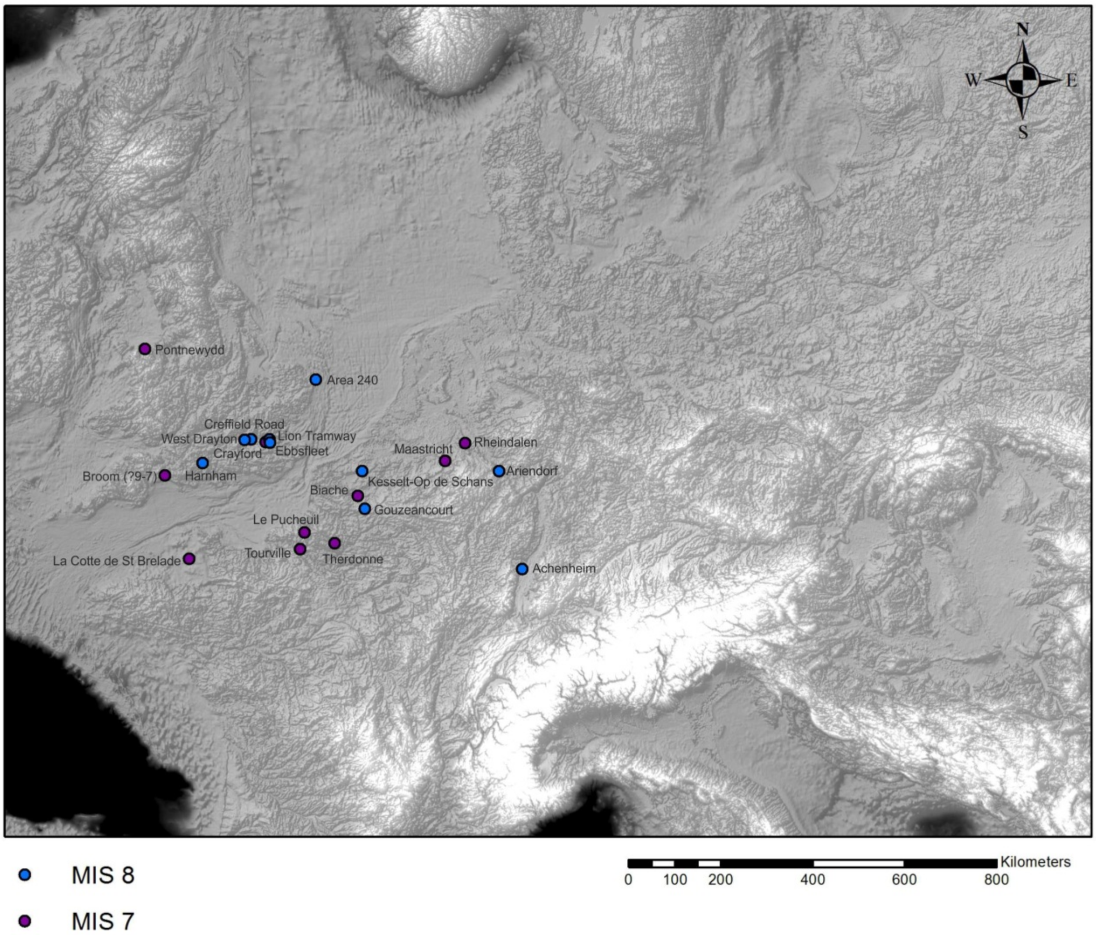

Figure 2.9 Sites from MIS 8/7 (MIS 8) and MIS 7/6 (MIS 7) in Britain and North West Europe

The sites that appear during late MIS 8 (possibly early MIS 7) are characterised by the early appearance of Levallois technology: Ebbsfleet (Scott *et al.* 2010), Lion Tramway Cutting (Schreve *et al.* 2006), West Drayton and Creffield Road (Scott 2006), the former two both in demonstrably open environments. However, the (rare) persistence of handaxe technology is also seen at Harnham in open and cool conditions (Whittaker *et al.* 2004).

MIS 7 (243 - 191ka)

The interglacial of MIS 7 presents a different picture. This interglacial has a complex history of warming and cooling (Section 2.3.3.1) with the Norton –

Brighton raised beach deposits indicating high sea levels in the Channel for at least some of the stage (Bates *et al.* 1997; 1998; 2000; 2003; 2010).

Archaeologically, few sites in Britain or the Continent exist during the warm phase of MIS 7, with most British sites within the warming limb of the interglacial (e.g. Figure 2.9: Crayford [Scott 2006] and Pontnewydd [Green 1984; Aldhouse-Green *et al.* 2012]) or at the MIS 8/7 transition. The dominant technology being used was Levallois, although handaxe manufacture is also seen at Pontnewydd. Sites on the continent are less prevalent at this point (although see Le Pucheuil [Ropars *et al.* 1996]) but increase in number through mid-MIS 7 and the transition to MIS 6 (e.g. Figure 2.9 -2.10, Maastricht C&K [van Kolfschoten and Roebroeks 1985], Tourville [Guilbaud and Carpentiere 1995], Rheindalen [Bosinski 1995] Therdonne [Scott and Ashton 2011], Biache [Tuffreau and Somme 1988] and Pecheuil [Ropars *et al.* 1996]).

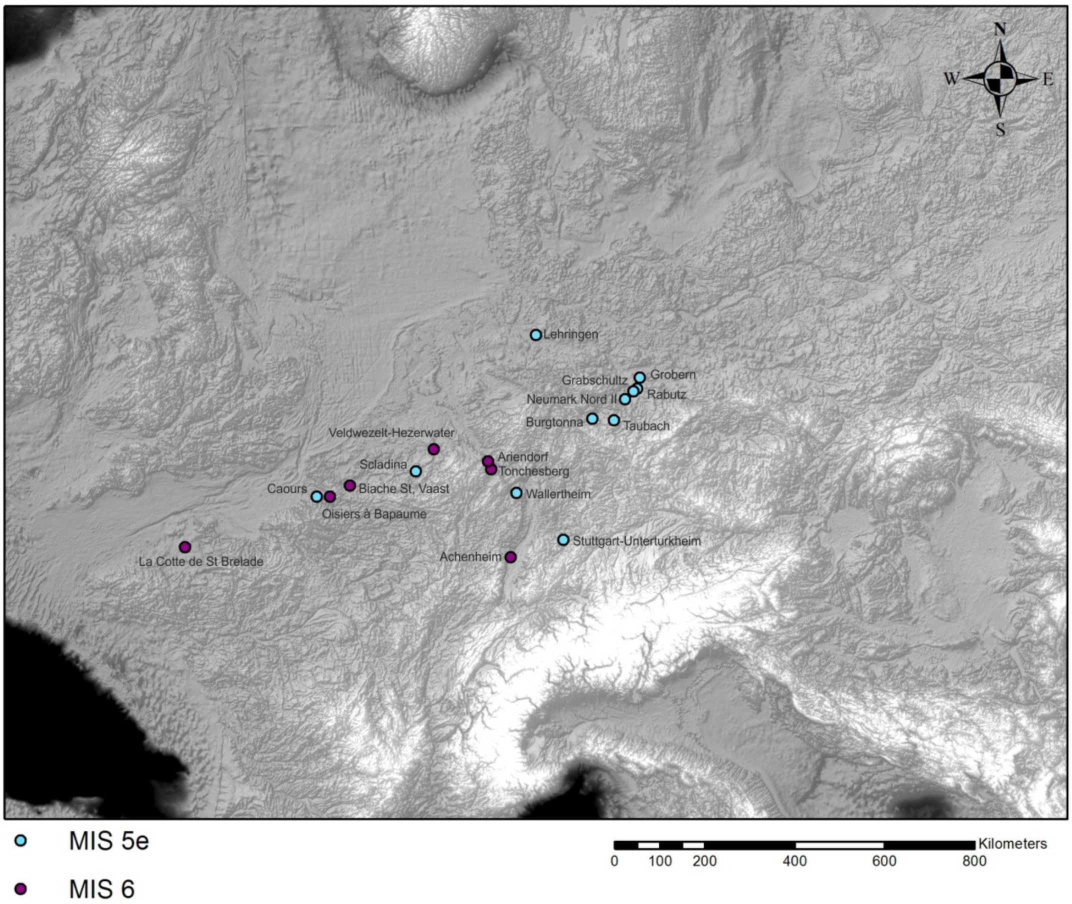

Figure 2.10 Sites from MIS 6 through MIS 5e, showing the abandonment of Britain at this time

Roebroeks and Speelers (2002) have argued that the prevalence of sites at this cooler transitional stage could be due to increased sedimentation rates and loess cover in cooler periods, but this could also reflect the increasing adaptation to cooler, more open environments that is seen throughout the Early Middle Palaeolithic. Of course, there are always exceptions to these rules, such as the site of Maastricht Belvedere in the Netherlands with faunal elements indicating warm and wet interglacial conditions (although an early TL date of 250-290ka places it within MIS 8 [Huxtable and Aitken 1985]) and where hominins are applying a range of Levallois techniques to varied situations (Schlanger 1996; Scott *et al.* 2011). For Britain, the apparent absence of hominins in late MIS 7 is perhaps due to a situation of isolation from the continent at the time, or to the movement-barrier of the Channel River once sea levels had fallen at the start of MIS 6. Climatic reasons for an absence in phases within much cooler periods of MIS 6 would appear to be negated by the presence of archaeological sites in areas of northern France (e.g. La Cotte de St Brelade [Callow and Cornford 1986; Bates *et al.* 2013]), perhaps occupied through the utilisation of fire (Herisson *et al.* 2013). Perhaps La Cotte was offering hominins something unique which made occupation during these inhospitable times worthwhile; access to and visibility across a vast landscape, ideal for the hunting of prey (Scott *et al.* 2014).

The site of Area 240 appears to sit within the transitional phase of MIS 8/7 and represents the only submerged Palaeolithic site in the UK sector of the southern North Sea to-date (Figure 2.9, Text Box 1; Russell and Tizzard 2011). Approximately 13km off Great Yarmouth and with cordate handaxes, flakes (including levellois) and faunal remains, this site is thought to have existed within an estuarine environment on the banks of the Palaeo-Yare River.

Geographically there are also some interesting patterns to note with regard to Levallois versus handaxe manufacture within this period. Handaxes still persisted in some areas (Monnier 2006), although in North West Europe they are generally rare (Scott 2011) and where they do occur alongside Levallois technologies they are in reduced quantities (Ruebens 2011). Their east – west patterning has drawn the attention of some researchers. The areas where handaxes persisted were limited to the west of Britain (e.g. Broom, Dorset dated to MIS 9-7 [Toms *et al.* 2005; Hosfield and Chambers 2009] and Harnham, Wiltshire [Whittaker *et al.* 2004]) and also to the west of France, with Levallois technology dominating heavily to the east (>1000 in the Thames Valley and only 67 in the Solent Basin [Ashton *et al.* 2011]). McNabb (2007) and Ashton *et al.* (2011) have suggested that this may reflect the routes of hominins with differing toolkits throughout Europe, with movement from northern and western French rivers and the English Solent, both feeding into the Channel region, although this hypothesis requires further testing. If a true pattern, this would appear to provide more evidence of handaxe manufacture towards the west, contrasting with those following rivers from the east of England and Belgium and the Netherlands (Scott and Ashton 2011), dominated by Levallois technology, feeding into the North Sea basin. These patterns, if proved to be robust, may indicate the migration patterns of groups of Levallois- versus handaxe-using hominins.

The evaluation of archaeological signatures from the southern North Sea basin as well as the Channel region could have significant implications for the analysis of these patterns. Interestingly, Area 240, thought to date to c.250ka, is argued to have both Levallois and handaxe technology (De Loecker 2010), as does the site of Pontnewydd (Green 1984; Aldhouse-Green *et al.* 2012); it is not a clear cut matter.

2.3.3.3 Abandonment (MIS 6 – late MIS 4, c.191 – 64ka)

The period marking out the Early and the Late Middle Palaeolithic is defined by a period of apparent abandonment of Britain (Currant 1986; Wymer 1988; Sutcliffe 1995; Currant and Jacobi 2001; Ashton 2002; Ashton and Lewis 2002; White and Jacobi 2002; Lewis *et al.* 2011 cf. Wenban-Smith *et al.* 2010) from MIS 6 until late MIS 4 and including the Mediterranean-like environments of the Eemian (MIS 5e).

Despite the intensive investigation of palaeoenvironmental deposits from the Eemian (e.g. Trafalgar Square [Franks *et al.* 1958; Franks 1960], Victoria Cave [Currant and Jacobi 2001; Schreve 2001], Saham Toney [Ashton pers. comm.], Joint Mitnor [Currant and Jacobi 2001]), no evidence for hominin occupation has been found. Because of perceived difficulties of occupying heavily forested environments – for example, MIS 5e had a strong presence of *Carpinus*, a tree which brought a lot a shade (Wenzel 2007) making hunting and socialising more difficult; prey species would be more dispersed; there was high productivity but this was in the leaves of trees, not in their edible components - Gamble (1986; 1987) suggested that hominins may have avoided Britain at this time. However, their clear contemporary presence in German forested environments (e.g. Grobern, Lehringen, Taubach, Neumark-Nord II) as well as Caours in northern France (Figure 2.10, Antoine *et al.* 2006) makes this seem less feasible. Although it is possible that these environments show more dispersed prey species (e.g. Grobern, Lehringen), the inhabiting Neanderthals are certainly coping with them (Bynoe 2012).

An alternative hypothesis, which does not necessarily exclude that just described as a reason for at least decreased population, concerns access. As discussed, by the time of the Last Interglacial it seems that Britain was totally isolated at high sea levels (Meijer and Preece 1995; Gupta *et al.* 2007). With the severity of the preceding MIS 6 (Dansgaard *et al.* 1993) precluding occupation and the rapid rise in sea levels at the start of MIS 5e (Streif 1989; Siddall *et al.* 2006), was there just not enough time for hominins to re-occupy this corner of the European landmass? The site of Veldwezelt-Hezerwater, Belgium, demonstrates occupation at a point within the Zeifen interstadial (a few thousand years long) during the final stages of MIS 6 (Figure 2.10, Bringmans 2007; Meijs, 2011), implying that hominins were capable of reaching these latitudes relatively quickly. There is nothing to suggest, however, that Neanderthals would have reached this far north in large numbers; there is no reason to think that Neanderthals would have been rushing for Britain as soon as the ice started to melt.

Given these issues of access, it is unlikely that hominins were able to reach Britain during the Eemian, or at least not in any great numbers. Roebroeks and Speelers (2002) have pointed to the dearth of available accommodation space, or catchment areas, for sediment from this period in North West Europe relative to the German glacial landscape of kettle holes and lakes. With the lack of a second half of interglacial environmental evidence in Britain (nothing exists from the *Carpinus* stage - mid-interglacial onwards [Bynoe 2012]) this lack of accumulation of evidence may have a part to play in the picture of absence. This does seem unlikely, however, given hominins' persistent absence throughout the accumulated initial stages when access would also not have been an issue.

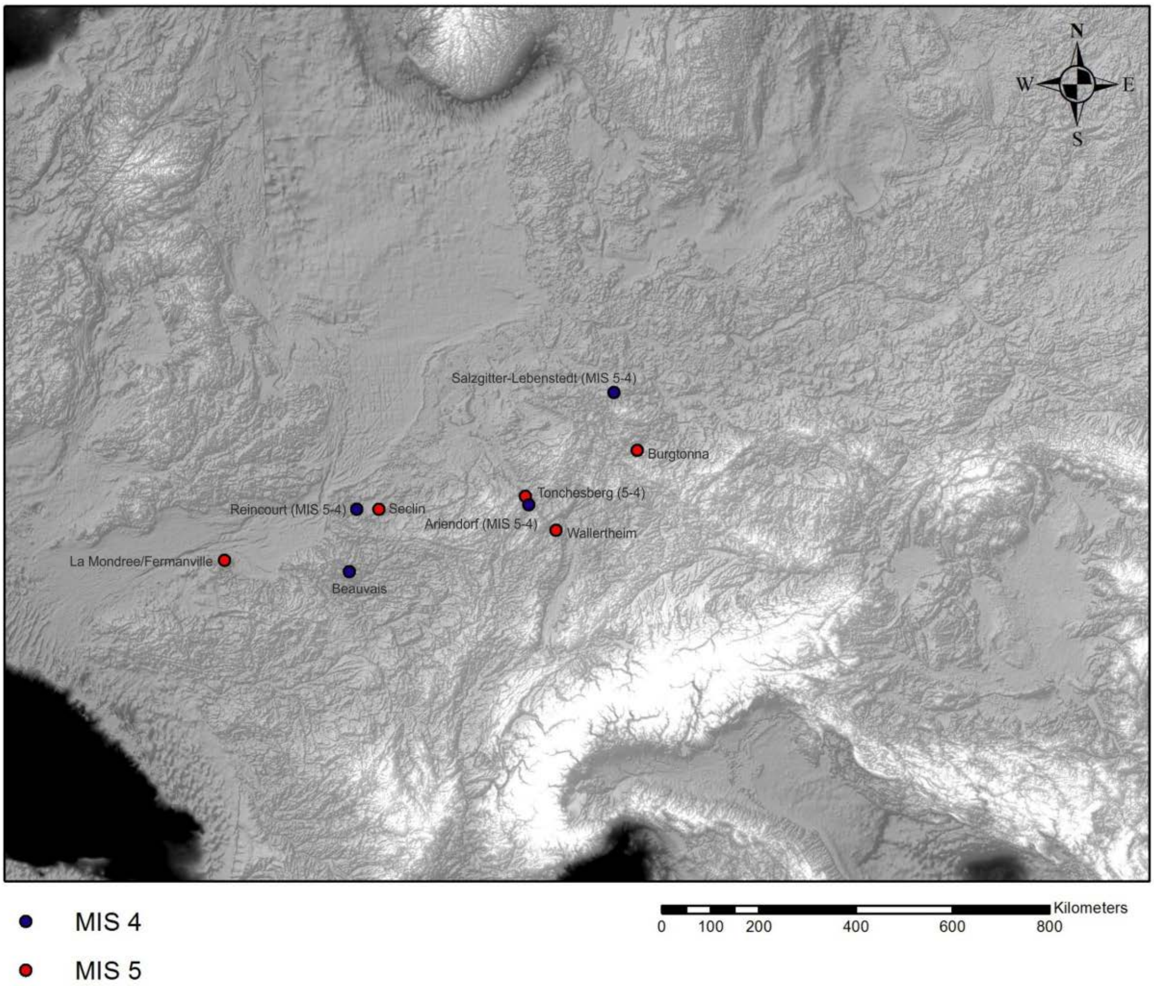

Figure 2.11 Sites in North West Europe during MIS 5d-a and MIS 4

The occurrence of sites towards the end of, as well as during, MIS 6 (e.g. La Cotte de St Brelade [Callow and Cornford 1986; Bates *et al.* 2013], Biache-saint-Vaast [Tuffreau and Somme 1988), may indicate occupation of areas now submerged in both the Channel and the southern North Sea. Furthermore, investigation of deposits from these areas may elucidate the environmental landscapes that were available during this time, as well as the changing configuration of the landmass, that may have provided context for hominins in these marginal areas.

2.3.3.4 Summary

Interesting patterns between the British and continental evidence emerge during this period with the potential for looking at the movement of different groups of hominins using different toolkits. The adaptation to cooler, more open environments, as seen through the changing faunal communities and introduction of species such as *Coelodonta antiquitatis* (woolly rhino), can arguably be associated with the development of technological strategies such as the adoption of Levallois, and this can be seen further by the development of faunal specialisation from MIS 7 onwards (e.g. Gaudzinski and Roebroeks 2000).

The patterns seen throughout this period may therefore indicate changing ecological preferences to cooler, more open environments with predictable herd species (e.g. Salzgitter Lebenstedt [Gauszinski and Roebroeks 2000]). If we return to the questions raised in Chapter One regarding palaeoecological preferences throughout the Palaeolithic, the analysis of archaeological sites on what would have been presumably productive, resource-rich landscapes across the southern North Sea basin may help to clarify hominin subsistence and ecological context within these environments.

Furthermore, despite an abundance of sites on the continent during these cooler periods (MIS 6 through MIS 4: Figure 2.11), occupation of Britain appears to be in decline (Ashton and Lewis 2002; Ashton *et al.* 2011) with the final sites occurring in MIS 7 before a long period of abandonment (Currant and Jacobi 2001; Ashton and Lewis 2002; Ashton *et al.* 2011). The existence of sites from the terminal stages of MIS 7, or even MIS 6 (e.g. Veldwezelt Hezerwater [Bringmans 2007]), implies the possibility of further sites below current sea-levels, and, if located, could help to shed light on this apparent abandonment.

2.3.4 Late Middle Palaeolithic (LMP, late MIS 4 – MIS 3, c.64 – 35ka)

The small-scale Neanderthal reoccupation of Britain in late MIS 4/ early MIS 3 (64-67 ka ± 5000BP from OSL at Lynford [Boismier *et al.* 2003; 2012], Figure 2.12) coincides with lowered sea levels and resumed peninsularity, as evidenced by the re-enriched faunal assemblages of the time (e.g. Pin Hole MAZ, Figure 2.5). This forms the start of the Late Middle Palaeolithic. Characterised by the classic Neanderthals, the Late Middle Palaeolithic lasts until approximately 35Ka with their disappearance from Europe, and is mostly encapsulated by the highly variable 'failed interglacial' (White and Jacobi 2002; Pettit and White 2012) of MIS 3.

From this period comes the first discovery so far of hominin fossils from the southern North Sea (Hublin *et al.* 2009). They were recovered from a context that also yielded faunal remains and stone tools, demonstrating the potential of these fossil-bearing deposits for preserving archaeology. It highlights in turn the importance of developing a broader and more ecologically inclusive understanding of these landscapes.

2.3.4.1 Environmental context

Much work over recent years has concentrated on the environments and occupation of MIS 3 (e.g. Van Andel and Davies 2003). Environmental evidence points to a relatively cold, open and treeless environment (hence 'failed interglacial'), although as previously noted there are exceptions to this picture (Section 2.2, Stuart and Lister 2001; Caseldine *et al.* 2008). Climatically, this is supported by evidence from the Greenland Ice Core Project (Bond *et al.* 1993; Dansgaard *et al.* 1993), North Greenland Ice Core Project (Andersen *et al.* 2006; Svensson *et al.* 2008) and Greenland Ice Sheet Project (Grootes *et al.* 1993), which show an unstable environment characterised by high amplitude oscillations of 500-2000 years (Dansgaard-Oescher events), of which fifteen are evident. These are contrasted with 6 records of cold Heinrich events, which are the result of massive discharges of ice from ice sheets (Heinrich 1988). The visibility of these fluctuations in the record may have to do with the more recent time-scale, meaning that less of the detail of the sediments is obscured. It is likely that these patterns of rapid changes were also occurring in earlier stages, but that we are simply not able to recognise them because of the age and depth of the sediments concerned (e.g. Oppo *et al.* 1998; McManus *et al.* 1999; Pettit and White 2012).

The high resolution picture of environmental variability throughout MIS 3, seen through the isotope record, is difficult to reconcile with the more coarsely-grained terrestrial record. The Stage 3 Project (Van Andel and Davies 2003) therefore developed three main phases through which these sites could be placed and viewed: an initial stage with a mild climate at ~59 -43ka; a second stage of increased variability, with more closely spaced D-O events from 42 – 36ka; and a final stage which descended into cold stages comparable with MIS 2 from 37ka onwards.

Sea levels during the milder phase, after the demise of the MIS 4 ice sheets, were at approximately 50m below modern sea level (bmsl), with a subsequent fall to around 60-80m bmsl after 50ka (Shackleton 2000; Waelbroek *et al.* 2002). Projecting this onto the modern bathymetry of the southern North Sea and Channel implies that Britain was connected to the continent throughout, allowing a constant interchange of floral, faunal and hominin species (Keen 1995). It is important to note, however, that this projection is fraught with difficulties and errors, given the bathymetric changes – such as subsidence, erosion and deposition - that would have occurred since (Busschers et al. 2008; Cohen et al. 2012).

This picture of a fluctuating climate is supported by the Pin Hole MAZ (Currant and Jacobi 2001), which is a mixture of cold-climate species such as *Mammuthus primigenius* (woolly mammoth), *Rangifer tarandus* (reindeer) and *Coelodonta antiquitatis* (woolly rhino) with forested species such as *Cervus elaphus* (red deer) and *Megaloceros giganteus* (giant deer), reflecting the existence of varied environments and climatic signatures throughout the stage. The presence of carnivores such as *Panthera leo* (lion) and *Crocuta crocuta* (hyaena) throughout the period also indicates a rich resource of herbivores (Turner 2009).

2.3.4.2 Archaeological picture

Archaeologically speaking there are relatively few sites when compared with the Continent (Figure 2.12), and the Neanderthal occupation of the Late Middle Palaeolithic in Britain appears to be intermittent and low-density (Roe 1981; Wymer 1988; Currant and Jacobi 2001; 2002; Ashton 2002; White and Jacobi 2002;

Wragg-Sykes 2009; White and Pettit 2011; Pettit and White 2012). Of course, areas of intensive occupation like South-West France are the exception rather than the rule in this period (e.g. Le Moustier, Pech de l'aze, Combe Grenal [Soressi *et al.* 2002), with most other areas of Europe displaying small assemblages with densities varying between up to 400 lithics at Saint-Brice-sous-Rânes but around 1 per m^2 at Oosthoven (Belgium) (Cliquet *et al.* 2009; Wragg-Sykes 2009). The comparison of these areas is potentially unfavourable because the presence of long cave assemblages in South-West France distorts the picture (Wragg-Sykes 2011). Given Britain's marginal location at the edge of the Neanderthal world, however, this pattern is not entirely surprising (Figure 2.12). Furthermore, much of the archaeology from this period in Britain was excavated by antiquarians with poor sampling strategies. This, combined with a subsequent loss of material, has caused significant difficulties in understanding and interpreting these sites (Pettit and White 2012).

Given the small assemblage sizes and small number of sites, it would seem logical that population sizes must also have been low (Pettit and White 2012; cf. Gamble 2002): the record has been argued to reflect small groups of highly mobile Neanderthals (Wragg-Sykes 2009; 2011). The lithics are characterised by a lack of Levallois or backed knives, but regular presence of bifaces, including distinctive *bout coupés,* which are the hallmark of the recolonisation of Britain in the Late Middle Palaeolithic (White and Jacobi 2002; Ruebens 2012). Many of these sites are within cave systems, the most significant being Robin Hood's Cave within the Creswell Crags system, but these appear to record ephemeral visits, possibly because of the co-occurrence of hyaenas (White and Pettit 2011, 68). Open-air sites are also small in density and number apart from the early MIS 3 site of Lynford Quarry where 70 bifaces and 489 flakes (some retouched) were found associated with a Pin Hole MAZ (Boismier *et al.* 2003; 2012; Smith 2012; Ruebens 2013).

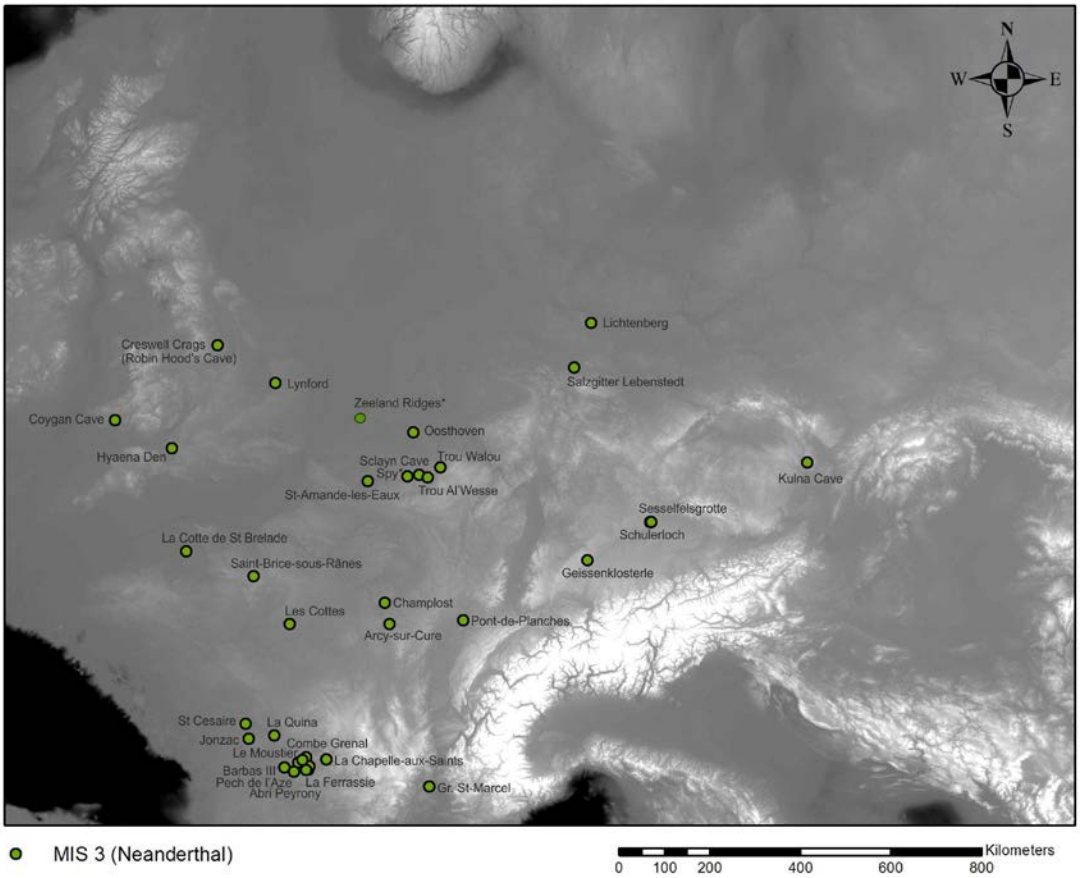

Figure 2.12 Sites from the Late Middle Palaeolithic of MIS 3, those with asterix's have yielded Neanderthal fossils. British sites are generally dominated by small numbers of lithics, with Coygan Cave having as few as 5 and Hyaena Den with 11 (although Lynford is the exception, with 2700). In contrast, European sites such as Les Amand-les-Eaux have 10,000 and Saint Brice sous Ranes has c.100,000, although there are still smaller assemblages, such as Villeneuve-l'Archevêque with 130.

In contrast with the preceding Early Middle Palaeolithic, the Late Middle Palaeolithic in Britain therefore sees the return of Neanderthals with a completely different toolkit, and despite an absence of Levallois, the concepts of flexibility and mobility still appear to hold true with a highly curated biface-centred technology (Boeda *et al.* 1990; Soressi and Hays 2003; Pettit and White 2012), perhaps relating to incursions of small numbers of Neanderthals into these unfamiliar territories (Pettit and White 2012). Although demonstrating the use of a high proportion of local materials for the construction of less formalised tool types (*ibid.*), typologically the sites fit into the broad Mousterian of Acheulean Tradition

(MTA), found from South-West France to the Netherlands (Ruebens 2012; 2013), the British variety mainly characterised by *bout coupé* handaxes (e.g. Scuvee and Verague 1988; Boismier *et al.* 2012).

It is interesting that the British record has similarities to that of the continent, but its own distinct signature of *bout coupé* handaxes yet no backed knives or Levallois (Ruebens 2012; 2013). With Britain at the furthest edge of their world, is this unique pattern linked to the isolation of these populations? The LMP in the Netherlands, for example, although sparse and badly understood, demonstrates the occurrence here of classic Mousterian handaxes, but no *bout coupés*. Similarly, but with a far richer record, northern French sites are dominated by bifacial tools (e.g. Villeneuve-L'Achevêque A and Lailly <Beauregard> A [Depaepe 2007], Saint-Brice-sous-Ranes, [Cliquet *et al.* 2009]). Belgium, on the other hand, presents an interesting mix of bifacial tools (such as classic handaxes) occurring alongside backed and leaf-shaped tools, which perhaps suggests a region of mixed cultural traditions (Ruebens 2012; 2013). The detail in assemblages of this time may therefore give a better indication of the movement of hominins across these landscapes.

Given the paucity of sites in Britain, it is interesting to note several hominin fossils from MIS 3 from the surrounding areas of the continent. The Neanderthal remains from Belgium, all recently radiocarbon dated between 40 and 36ka uncal. BP (Spy, Trou Walou, Goyet [Pirson et al 2011]) as well as those (OSL dates) from La Cotte de St Brelade from the second half of MIS 3 between 48ka and 25.7 ±3.0 ka (Bates *et al.* 2013) provide evidence for the existence of groups of Neanderthals in extremely close proximity to Britain. Even more significant is the spectacular find of the Zeeland Ridges Neanderthal brow ridge as well as *bout coupé* handaxes and a Later Pleistocene faunal assemblage from the Zeeland Ridges in the North Sea (Text Box 1, Hublin *et al.* 2009). Although with no formal date available, this fossil is assumed on the basis of related faunal groupings and their associated dates to date from the Late Pleistocene, and, from correlation with mapped offshore deposits, potentially from 50-30ka BP (Hijma et al. 2012). Its provenance from the submerged zone, c.15km from the Dutch coast, has implications for the preservation of deposits and archaeology of Palaeolithic date in this area, and corresponds with the many Later Pleistocene faunal remains that are regularly trawled up in the same broad locality (Verhart 2004; Mol *et al.* 2006; Peeters *et al.* 2009). This is the first incidence of the co-occurrence of a hominin fossil with faunal communities from the submerged zone and, as well as helping to define the associated Neanderthal ecology, demonstrates the relevance and therefore importance of investigating these faunal remains.

2.3.4.3 Summary

The Late Middle Palaeolithic of Britain contrasts with the record from North Western Europe - France especially - in its paucity and the picture of pulses of occupation. As with its earlier picture of occupation Britain appears to be intermittently occupied, possibly only during its mildest periods. This brings up the issue again of geographical position; with Britain at the most North Westerly point of the continent, Neanderthals would have been at the very edge of their range, presumably with smaller populations reflected by the fewer numbers of sites (or at least sites with smaller numbers of finds [Pettit and White 2012]). This pattern, when seen against that of neighbouring landscapes, makes investigating the now-submerged zone ever more intriguing, especially with the associated faunal and hominin finds from the Zeeland Ridges.

2.3.4.4 Transitional industry (MIS 3, c. 38-35ka)

The end of the Late Middle Palaeolithic and the start of the Upper Palaeolithic, still within the climatic zone of MIS 3, are marked by the demise of the Neanderthals and the first appearance of *Homo sapiens* across Europe (approximately 45-35ka BP). The general lack of associated fossil material during the Palaeolithic, with this period being no exception, has meant that this transitional time is plagued by issues of who-made-what. Debates over lithic industries which appear more technologically advanced, such as the Châtelperronian (e.g. Mellars *et al.* 2007; Higham *et al.* 2010; Bar-Yosef and Bordes 2010; Hublin *et al.* 2012), concentrate on the issues of behavioural complexity among species: whether Neanderthals were the independent authors, whether they were acculturated by modern humans, or if the industries were, in fact, created by moderns. The British record, although impoverished, does not escape these debates and contains a significant proportion of a so-called 'transitional' industry (Flas 2011). Recent advances in Radiocarbon dating (e.g. Higham *et al.* 2006; Talamo *et al.* 2012) have made a significant contribution to the resolution of debates surrounding its makers.

2.3.4.4.1 Archaeological picture

The earliest marker of the Early Upper Palaeolithic is the presumably Neanderthal-made leaf point assemblages. Found across Western and Eastern Europe (Figure 2.13), these have their typological roots in the Middle Palaeolithic and may form a northern and central European aspect of the more standardised transitional lithic technology seen across Europe at this time, such as Ulluzian (Riel-Salvatore 2009) and the Châtelperronian (Harrold 1983; 1989; Pelegrin 1990; 1995; Pelegrin and Soressi 2007; Soressi 2005; Hublin *et al.* 2012; Talamo *et al.* 2012; Roussel 2013). Given the similarities of these leaf point assemblages across Britain – Belgium – Northern Germany, this phenomenon is now grouped under the heading Lincombian–Ranisian–Jerzmanowican (LRJ [Flas 2011; Pettit and White 2012]). A second, British component of this technology is blade points, or blade leaf points (Jacobi and Higham 2011). These appear to be relatively basic in terms of retouch and, given that they are generally mutually exclusive, are perhaps a response to local raw materials forming taxonomically different entities of the British LRJ (Pettit and White 2012).

Continental dates for the LRJ are 42-44ka BP (Joris and Street 2008; Flas 2008), with a similar pattern of dates from the British sites of Kent's Cavern, Bench Quarry and Badger Hole (Jacobi *et al.* 2006; Higham *et al.* 2011), the most recent and most reliable date associated with the industry now coming from Glaston, Leicestershire at ~42-44ka BP (Cooper *et al.* 2012). These dates demonstrate that this is a technology and occupation that is distinct from that of the Late Middle Palaeolithic and from the *Homo sapien*-made Aurignacian (contrary to how they had commonly been considered [Allsworth-Jones 1990; Aldhouse-Green 1998]). In terms of their distribution they are widespread across Britain, with their northern extent a likely result of the limits of the LGM (Figure 2.13, Pettit and White 2012).

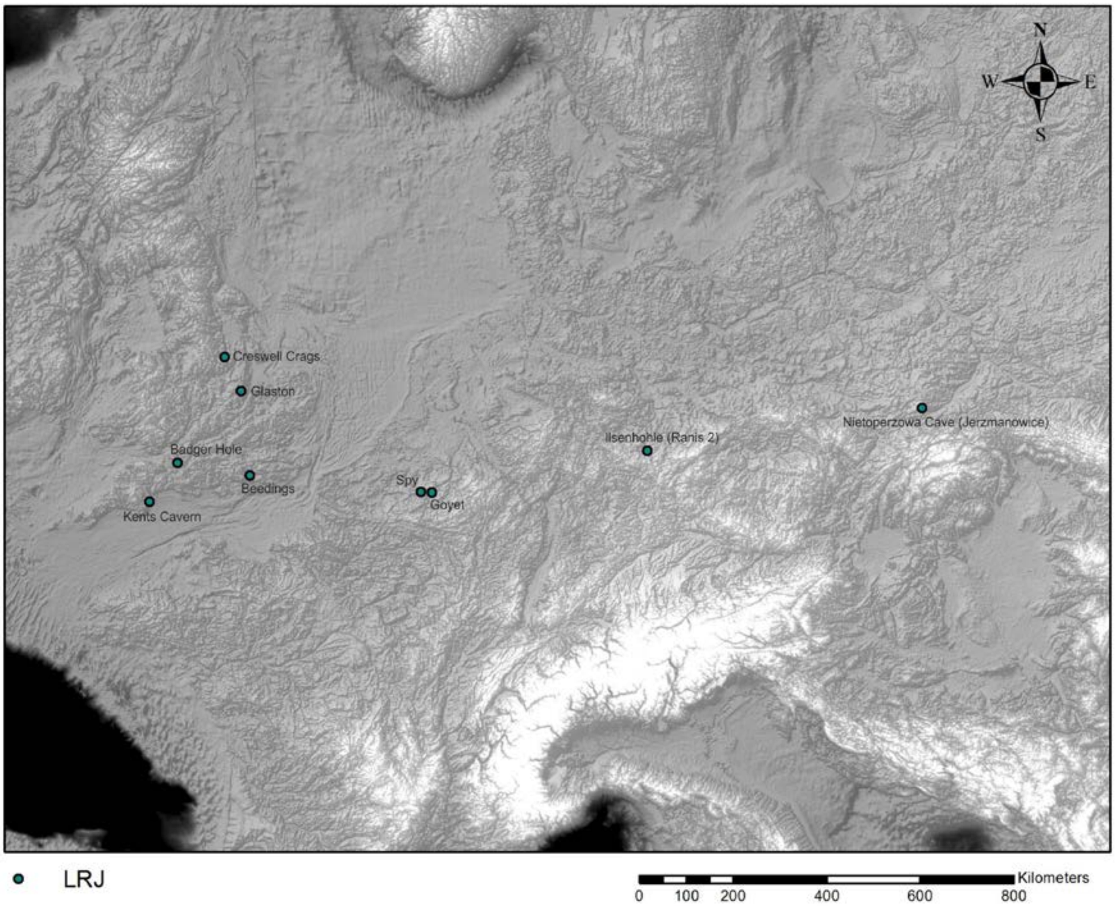

Figure 2.13 Distribution of LRJ sites throughout North West Europe

Although well dispersed, the majority of the find-spots are associated with single artefacts only, with the exception of a few more significant sites: Beedings (n=2300) and Glaston (n=83) (Cooper 2004; Cooper *et al.* 2012; Jacobi *et al.* 2007; Pope 2008; Pope *et al.* 2013). However, when compared with the continent, LRJ assemblages are remarkably high in number (Flas 2011), possibly because of their non-recognition and therefore absorption within other, mixed assemblages in Europe (Flas 2011).

Given the dates (44-42ka BP) it is likely that the LRJ occupation of Britain was a very brief phenomenon, which occurred during a distinct period after the Late Middle Palaeolithic and before the arrival of the Aurignacian and the final demise of Neanderthal populations in Britain.

2.3.5 Early Upper Palaeolithic (EUP: MIS 3 – 2, c.36 – 26ka)

The start of the Early Upper Palaeolithic is recognised by the spread of Aurignacian technology across Europe, now accepted to be associated with the corresponding spread of *Homo sapiens* (Davies 2001; Conard and Bolus 2003; Mellars 2005; Joris and Street 2008). With the earliest British date at approximately 35Ka BP, the Early Upper Palaeolithic of Britain can be viewed as part of the expansion of Aurignacian-using hominins through Europe, with the earliest dates in southern Europe at ~42ka BP (Joris and Street 2008).

The Early Upper Palaeolithic of Britain and much of northern Europe comes to an end with the start of the Last Glacial Maximum (24–18ka BP) and its associated period of abandonment of much of northern Europe. As with the preceding Late Middle Palaeolithic in Britain, the Early Upper Palaeolithic is characterised by intermittent and small-scale occupation patterns.

Despite lying within the range of radiocarbon dating, with its increasing resolution (Higham *et al.* 2006; Talamo *et al.* 2012), the chronology of the Early Upper Palaeolithic, and even the Late Upper Palaeolithic, is not wholly reliable, often as a result of stratigraphic uncertainty (e.g. KC4, Kents Cavern [Higham *et al.* 2011]). The defining markers of the Early Upper Palaeolithic are therefore lithic typologies and at this stage these can also be clearly associated with a European counterpart (Figure 2.14).

2.3.5.1 Environmental context

The period from 38-28ka BP has at least eight recognised interstadials from the NGRIP record, GI8-3 (Svensson *et al.* 2008). It is most likely that hominin expansion occurred during the warmer periods (GI7, GI5, GI3), but, given the difficulties of dating the associated archaeology, it is currently impossible to resolve this question. Dinnis (2008) has suggested that the Aurignacian phase in Britain is correlated with one such phase (a phase of warming known as GI7), but without further fieldwork and the identification of new sites with modern excavation techniques this remains an educated guess.

In terms of the MIS 3, three-phase model mentioned above (Section 2.3.4.1 [Van Andel and Davies 2003]), the period of the Aurignacian in Britain sits within a phase of climatic deterioration, perhaps explaining the relative paucity of sites compared with the continent. Despite this deterioration, the presence of organic deposits just south of the margins of the British-Irish Ice Sheet demonstrate that the open tundra landscape that was so characteristic of MIS 3 persisted until the LGM (Chiverrell and Thomas 2010).

As with the preceding Section 2.3.4, this period was characterised by the variable Pin Hole MAZ (Currant and Jacobi 2001; 2011). However, there are some distinctions between the two, as would be expected by the increasing climatic deterioration: *Coelodonta antiquitatis* (woolly rhinoceros) and *Crocuta crocuta* (hyaena) appear to have become extinct in Britain by 36-37ka BP (Stuart and Lister 2007). Furthermore, part of a mandible of *Homotherium latidens,* the scimitar-toothed cat, has been found in the North Sea, south-east of the Brown Bank and dated to ~31-32ka BP (Reumer *et al.* 2003), which indicates the presence of this species as late as the Late Pleistocene.

The changes that take place regarding this MAZ, perhaps identifiable through the increased accuracy of dating methods (Talamo *et al.* 2012) and the large number of climatic fluctuations identified for MIS 3, serve as a good reminder that these assemblage zones are based on the amalgamation of evidence from several sites over long periods. They represent the range of species present throughout a period but they do not necessarily define specific faunal communities that you would expect to find.

The Dimlington Stadial MAZ represents the species that you would expect to find in the early part of MIS 2 and, as a result of the marked deterioration of climate, reflects a massively impoverished faunal record (Figure 2.5).

2.3.5.2 Archaeological picture

2.3.5.2.1 The Aurignacian

Signalling the arrival of *Homo sapiens* across Europe (Davies 2001; Conard and Boulas 2003; Mellars 2005; Joris and Street 2008), the Aurignacian is generally defined on typological grounds, arriving in the west of Europe by approximately ~36ka BP after apparently dispersing from the south and east (Joris and Street 2008; Flas 2008; Dinnis 2009; Flas *et al. in press*). It is therefore distinguished from the preceding LRJ by a hiatus of several thousand years, but is also geographically defined, with the Aurignacian being very common in northern continental Europe but rare in Britain (Flas 2011).

The presence of *burin busqués* and the associated Dufour bladelet as well as the association of typically Aurignacian carinated end-scrapers characterise the British Aurignacian (Pettit and White 2012, 400). This is a similar picture to that seen in Northern France, but, as usual, the continental picture is far less impoverished (Figure 2.14). In Britain these assemblages are found in small numbers (often just single finds) at the sites of Ffunen Bueno, north Wales (n=1), Goat's Hole, Paviland (n=41), Hoyle's Mouth, near Tenby (n=1) and Kents Cavern, Devon (n=3) (Jacobi and Pettit 2000; Dinnis 2009; Dinnis 2012; Pettit and White 2012). In further contrast with the preceding LRJ, these Aurignacian sites are exclusively restricted to the South West of Britain (Figure 2.14).

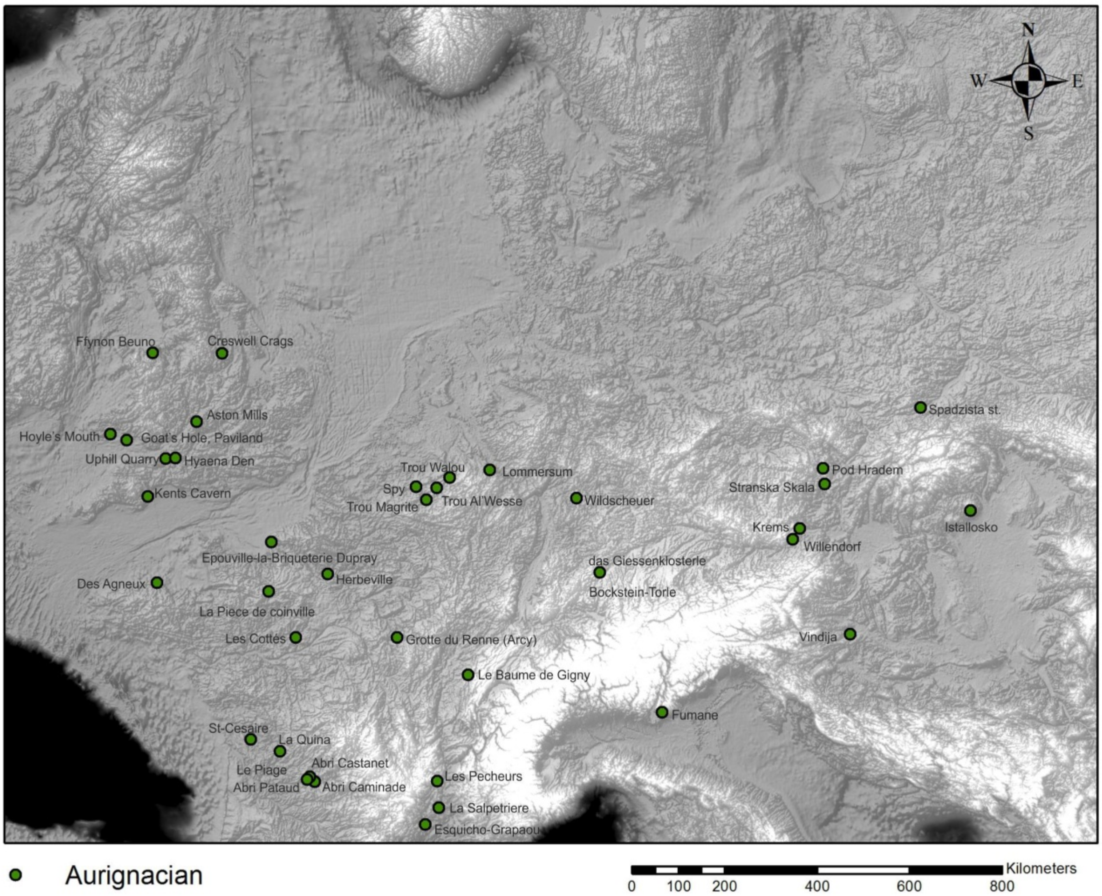

Figure 2.14 Aurignacian sites from MIS 3

The British record is impoverished in terms of both numbers and density of sites but also for the lithic and organic diversity present, with far more examples of organic technology in use on the continent (Pettit and White 2012). However, the sites of Uphill Quarry and Hyaena Den, Wookey Cave have yielded bone and antler points, which not only have extremely similar dates (31,731 +/_ 250 and 31,550 +/- 340 radiocarbon years respectively [Higham *et al.* 2006]) but are also typologically similar to one another and to those found on the continent (Jacobi and Pettit 2000; Jacobi 2007).

Given this westerly spatial distribution and the paucity of sites, it seems apparent that this phase of Aurignacian occupation of Britain was relatively brief and represents ephemeral occupation at the edge of hominin range, possibly dealing with ecologies and landscapes that were verging on the unfamiliar. However, there is a definite lack of well-dated assemblages, and assemblages in general, making this comparison all the more difficult. This may, of course, be subject to change with the future location and excavation of sites (if they exist).

Parallels exist with continental sites, such as Paviland-style burins at Spy in Belgium (Dinnis 2009) and Le Piage in South West France (*ibid.*), which appear to link the populations of the continent with those sporadically exploiting Britain. This has led Pettit (2008) to suggest a possible Atlantic coastal dispersal into familiar landscapes with predictable patterns of prey movement. This hypothesis then raises questions about the amount of archaeology that may now be submerged in the region of the Channel, which remained a river system throughout this period.

2.3.5.2.2 Gravettian

The final phase of occupation before the occupational hiatus of the LGM relates to the Mid Upper Palaeolithic Gravettian. Dated to 33-34ka BP (with nothing convincing after 33ka, probably because of the increasingly glacial environments [Pettit and White 2012]), this occupation occurred well into the growth of the British Ice Sheet and, as with the previous forays, appears to have been very sparse. The assemblage associated with the 'Red Lady', a male burial in Goat's Hole, Paviland, is from the only site dated to this period that has yielded an actual assemblage and it is dated to 33.3-34ka BP (GI5 or 6 [Jacobi and Higham 2008]).

All other evidence for occupation is based on typology: tanged Font Robert points made on blades, also a distinctive part of the Gravettian seen contemporaneously on the continent (Pettit and White 2012). The fauna present at Gravettian sites represents a rich mammoth steppe, so although the distribution of Gravettian material seems dispersed relative to its Aurignacian predecessor, this is perhaps due to its purpose as a hunting technology associated with highly mobile groups of hominins active in these harsh environments.

The distribution of this Gravettian material has more of an eastern spread than the preceding Aurignacian (Figure 2.15), perhaps indicating affinities with hominins moving from areas such as Belgium (Maisières Canal) and the Paris Basin (Cirque de la Patrie [Jacobi 1980; Jacobi *et al.* 2010]). This would make the deposits now submerged in the southern North Sea and eastern Channel more relevant to looking for hominin and environmental evidence for this period. Given the small numbers of finds for this period, however, these interpretations must be made with a degree of caution.

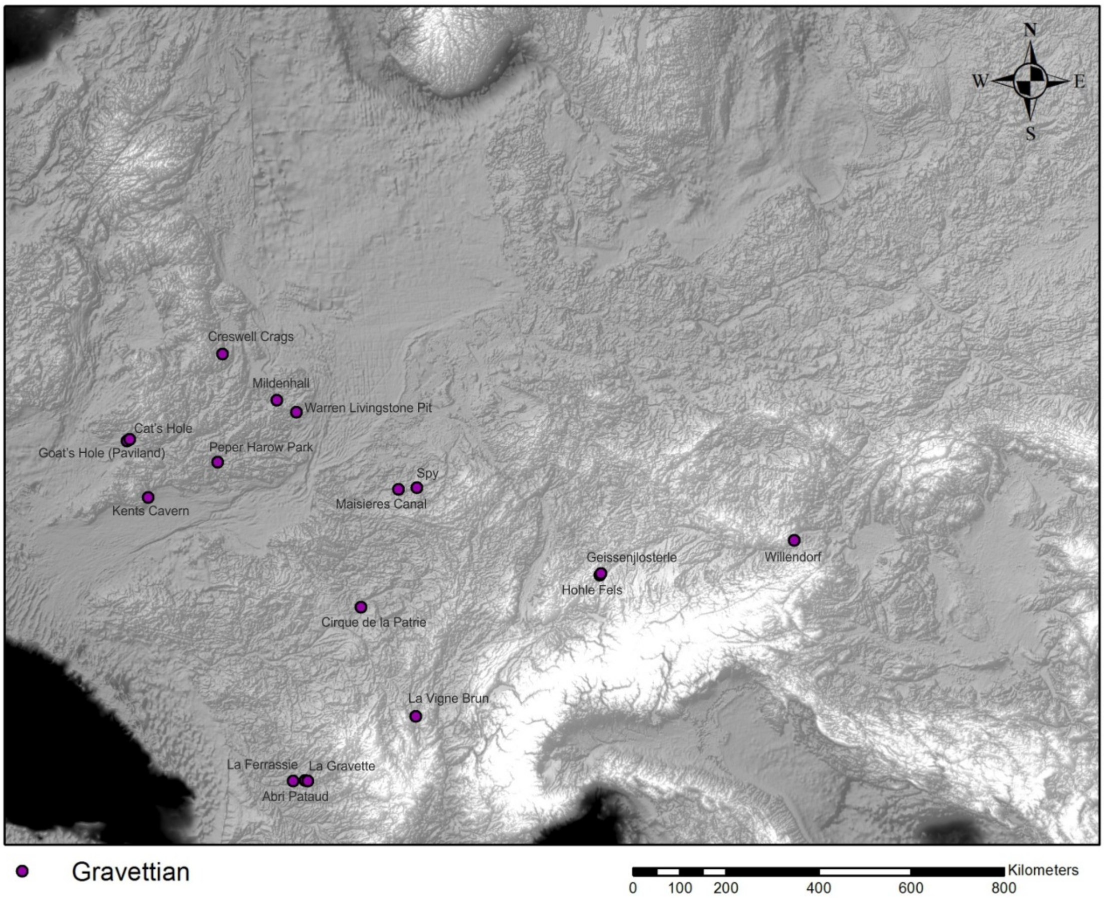

Figure 2.15 Gravettian sites during the EUP

2.3.5.3 Summary

Overall, the Early Upper Palaeolithic is at present characterised by ephemeral phases of archaeology, temporally distinct from one another. The changing patterns of spatial distribution offer interesting insights into the movements of these groups of hominins, with the Neanderthal LRJ appearing to spread into Britain from the east and exploiting areas across all regions of the country, disappearing (forever, in Britain) by approximately 40ka BP. In contrast, the proceeding Aurignacian is very much spatially restricted to the west of Britain, possibly representing only a few forays this far north by modern humans following the rugged Atlantic coast. Finally, the picture of the Gravettian occupation appears to be far more dispersed. This is possibly the result of small groups of highly mobile hunters, perhaps moving from the East, following herds that were exploiting the mammoth steppe of these much colder periods. Each distinctive period of occupation highlights the discontinuous occupation of Britain and its status as a periphery of both Neanderthal and *Homo sapien* range.

Let us return to the questions raised in Chapter One. Given these patterns, what potential do the submerged landscapes of the southern North Sea hold for illuminating our understanding and interpretations? Dispersals of hominins from the east or west are assumed based on current site distribution, but movement across major fluvial zones such as the Channel, or the southern North Sea, can only be guessed at. An examination of the record from these submerged areas could help us to examine how hominins are dealing with these areas; do the confluent river systems present barriers, ecological niches, or both? Furthermore, how do the timings of these occupational episodes tie-in with the rest of the picture from North West Europe? These areas therefore have the potential to address questions which could add significant information to our understanding of Neanderthal and *Homo sapiens* dispersals through varied ecologies at the edge of their range.

2.3.6 Archaeological implications and relation to the submerged zone

The archaeology dealt with in this chapter covers a vast time span. It is not appropriate therefore to treat it exhaustively but simply to highlight the changing occupation patterns of various (usually not distinct) hominin species throughout the Palaeolithic of Britain and the near continent. Two clear themes emerge. The first is the very occasional nature of the occupation; even at periods relatively rich in archaeology there is no evidence to show that this is in any way continuous. Higher-accuracy dating methods may improve our ability to resolve the archaeological picture against the fine-grained environmental one, but at present this remains an unavoidable issue and would no doubt still leave us with thousands of years of apparent absence in each interglacial. The second theme is just that: the mismatch in resolution of data. This is seen clearly in the Lower Palaeolithic where dating techniques have much larger margins of error, or are relative, and reconciling archaeological data against a wider landscape picture relies on a best-fit approach. Although much of this resolution becomes clearer with decreasing age (for example, environmental and climatic records are far more detailed), dating for the Later Palaeolithic remains difficult; it often comes down to the context of dateable artefacts (e.g. fossils [Hublin *et al.* 2009], cut-marked bones, bone tools or ornaments), how these relate to the higher-resolution environmental proxies and also to the rapid typological changes and inferred hominin movement that is seen.

Britain therefore appears to be a peripheral area of occupation. This is not surprising given its geographical position. We should not see this negatively but, as highlighted by Pettit and White (2012), as an insight into how hominins through time have adapted and dealt with different environments. How we recognise and deal with the pattern of archaeology in these more marginal environments has important implications for how we interpret these signals: a small-scale record may not necessarily mean little occupation just as a lithic-rich site does not necessarily denote repeated occupation. In this sense too, it makes the record of the southern North Sea an invaluable resource both from the perspective of environmental proxies for areas where we have potentially no terrestrial equivalent, as well as from an archaeological perspective. The finds from Area 240 (Wessex Archaeology 2008; Russell and Tizzard 2011), the Zeeland Ridges (Hublin *et al.* 2009) and the Dutch Sector (Mol *et al.* 2006), as well as the faunal patterns presented through this research, all signify the preservation of a fragmentary and temporally-diverse submerged record over a vast area of seabed that was once terrestrial. Given the highly fragmentary terrestrial record, the investigation of these landscapes is crucial if we are to understand these dynamic peripheral landscapes and the hominins who demonstrably exploited them.

2.4 Conclusions

There have been fascinating developments in both the onshore and offshore records over the past decade. The Early Pleistocene record of Northern Europe has begun to emerge, giving archaeologists the information and evidence necessary to ask previously ignored or taboo questions, such as early hominin environmental tolerances, and the place of coastal interactions in the Palaeolithic. Submerged deposits as well as *in situ* archaeology of the hostile North Sea region are similarly reaching a point where their discussion is both accepted and necessary. However, these questions are still in their infancy. There is a severe dearth of archaeological investigation of the submerged areas from a pre-LGM Palaeolithic perspective (cf. Wessex Archaeology 2008; Russell and Tizzard 2011; Cliquet *et al.* 2011), which makes such research essential and long overdue.

To return to the questions highlighted in Chapter One, what can the current state of research add to them? Given the focus on an ecological approach to these early hominins, the questions are necessarily focused on preferences, adaptations and use of a landscape that we are only just beginning to explore. But a broader appreciation of the European archaeological record also emphasises what this pattern of discontinuous forays into northern latitudes means for hominin preferences and mobility. As it stands, we have a limited knowledge of *who* was occupying these areas, *why* they were here and *how* they were surviving, and with the traces of occupation extremely scarce it is not likely that the answers will be found any time soon. Examination of the submerged zone therefore has the potential to begin addressing these gaps in our knowledge.

The lack of previous research into the Palaeolithic of the southern North Sea means that this research starts from the very beginning, using all available data, from that of private collectors to the contents of the stores of the Natural History Museum, and creating an important resource for future research. This thesis will explore the distribution and patterning within the data available in order to ascertain the different levels at which it can be interrogated. The ultimate aim is to pin-point areas of seabed that have the best Palaeolithic potential.

There are many preconceptions that can cloud our perception of the offshore zone. Being characterised as one, single 'offshore' area renders it environmentally and archaeologically homogenous instead of recognising its spatial extent and diversity. Access to, and interpretation of, this resource is admittedly a challenge, but it is a challenge that must be tackled. It is essential that we begin to develop new methodologies to acquire this data and analyse it in conjunction with the evidence that we already have. This is not only a practical and methodological issue, but one of attitude and willingness to confront an unexplored aspect of archaeology. Whilst scientific techniques are advancing and providing us with ever more sophisticated means of imaging and deciphering submerged deposits, the archaeological questions that this allows us to address must remain our focus. Through investigating this archaeological material and addressing the ecological settings of the contemporary landscapes of early hominins, this work can provide new insights into fundamental questions in Palaeolithic research.

Chapter 3: Historiographical methods for Palaeolithic fossils

Chapter Two set out the main issues surrounding the submerged archaeology of the southern North Sea throughout the Palaeolithic, providing a review of the existing record as well as discussing the nature of the offshore deposits in which material is found. This chapter presents and discusses the main resource that we have from the UK sector of the southern North Sea, the remains of Pleistocene fauna, in the context of their recovery via the fishing and aggregate-extraction industries of the 19th and 20th Centuries. It presents a historiography of the development of the trawler fishing industry, as well as of the antiquarians who collected these more unusual catches.

Given the non-routine nature of the study area as well as the resource associated with it, the methods developed for this research are fairly unorthodox. The faunal specimens are almost entirely without detailed provenance, being, for example, from 'off Lowestoft' or 'off Great Yarmouth', they lack collection notes from their historical collectors and they are time-transgressive. Furthermore, their identification to species level is not always complete, with some of the specimens still undergoing analysis.

Despite these factors having led many people to believe that these data are without use, this research will demonstrate that this is not actually the case. However, in order to get the most information from this record it will be necessary to resolve a few crucial points:

- Where the material could derive from (in other words which areas of the seabed were being exploited throughout the 19th and 20th Century);
- How geographical differences in developments in the fishing industry may have influenced the different exploitation of these areas;
- How these differences in exploitation affected the recovery of specimens;
- How the specimens are distributed throughout museums' archives today;

- How both the modern locations, as well as the trawling ports the specimens were landed at, relate to the locations and lives of the antiquarians who were curating the material.

Using historical fishing sources, including contemporary charts, oral histories and historical documents, this chapter begins with a discussion of the favoured fishing grounds, as disclosed by oral history, that were exploited during this time, including an assessment of the relevance of these grounds to more historic periods of trawling. Most significant is the identification of specific fishing ground territories to particular ports. This enables us to link groups of specimens to groups of grounds. The discussion then moves on to the ways in which trawling techniques developed through time, in different locations.

Moving on from the fishing itself, the location of the specimens today is then presented: how they were located, collated and analysed. Finally, the important factor of the antiquarians is discussed; does where they were living and why they were collecting shed light on the ports that they were each collecting from? The level of information that they recorded may also depend on the reasons behind their interest; whether they were natural history enthusiasts (e.g. Rev.'s Layton, Gunn, Text Box 5), or general collectors of 'curiosities' (e.g. Colman, Text Box 5).

These methodological strands are then drawn together in Section 3.5, providing a framework within which we can begin to contextualise and place the collated specimens. This will demonstrate how we can address spatio-temporal patterning of the submerged resource in a way that completely alters our appreciation of the integrity of submerged deposits and facilitates a far more focused approach to the search for archaeology.

3.1 Fishing Locations

Having been largely overlooked since their initial acquisition, the first step for this methodology is to attempt to provide some broad context to the specimens in question. Understanding the locations favoured by trawlers across the southern North Sea is therefore necessary. This first section will address the range of potential locations the specimens have come from, which can be whittled down through the use of further historical evidence.

A reconstruction of the favoured grounds that were historically worked was derived from discussions with a local Lowestoft historian, David Butcher, as well as the information he had collated through a series of fishermen's oral histories during the 1970s (Butcher 1985). Plotting the results of this information has revealed the various areas of seabed exploited and this is presented in Figure 3.1.

The locations shown relate to fishing grounds throughout the early - mid 20th Century, but for this research the case is being made that they also relate to those finds (indeed the majority of the historic finds) from the mid-late 19th Century. This is argued on the basis of broad-scale changes to the seabed which, according to several recent studies of seabed morphology (Collins *et al.* 1995; Burningham and French 2009), as well as the historic charts evaluated as part of this research, are negligible at the scale of large bank morphologies.

Figure 3.1 Favoured fishing locations identified through the oral histories of Butcher (1985). Insert map at the top right shows the location.

3.1.1 Assessing the stability of fishing grounds through historic charts

A series of charts are held by the Lowestoft Records Office which refer to the local area (Lowestoft and Great Yarmouth) as well as the southern North Sea in general. Thirteen relevant charts were located and photographed, however none of these are specifically fishing charts. Despite this, these local-area charts can show small-scale changes to the seabed and indicate more localised areas of exploitation.

The chart makers Imray Laurie Norie & Wilson were also found to have retained copies of a series of their 18th, 19th and 20th Century charts, including a few 'Blue Back' fishing charts from the 1960s as well as detailed charts from throughout the 19th Century. In total, six charts were located and photographed from their archives. Through these charts, in combination with charts from the Lowestoft Records Office, it has been possible to assess the degree of movement of fishing grounds throughout the 19th and 20th Centuries in the areas indicated by Butcher (1985).

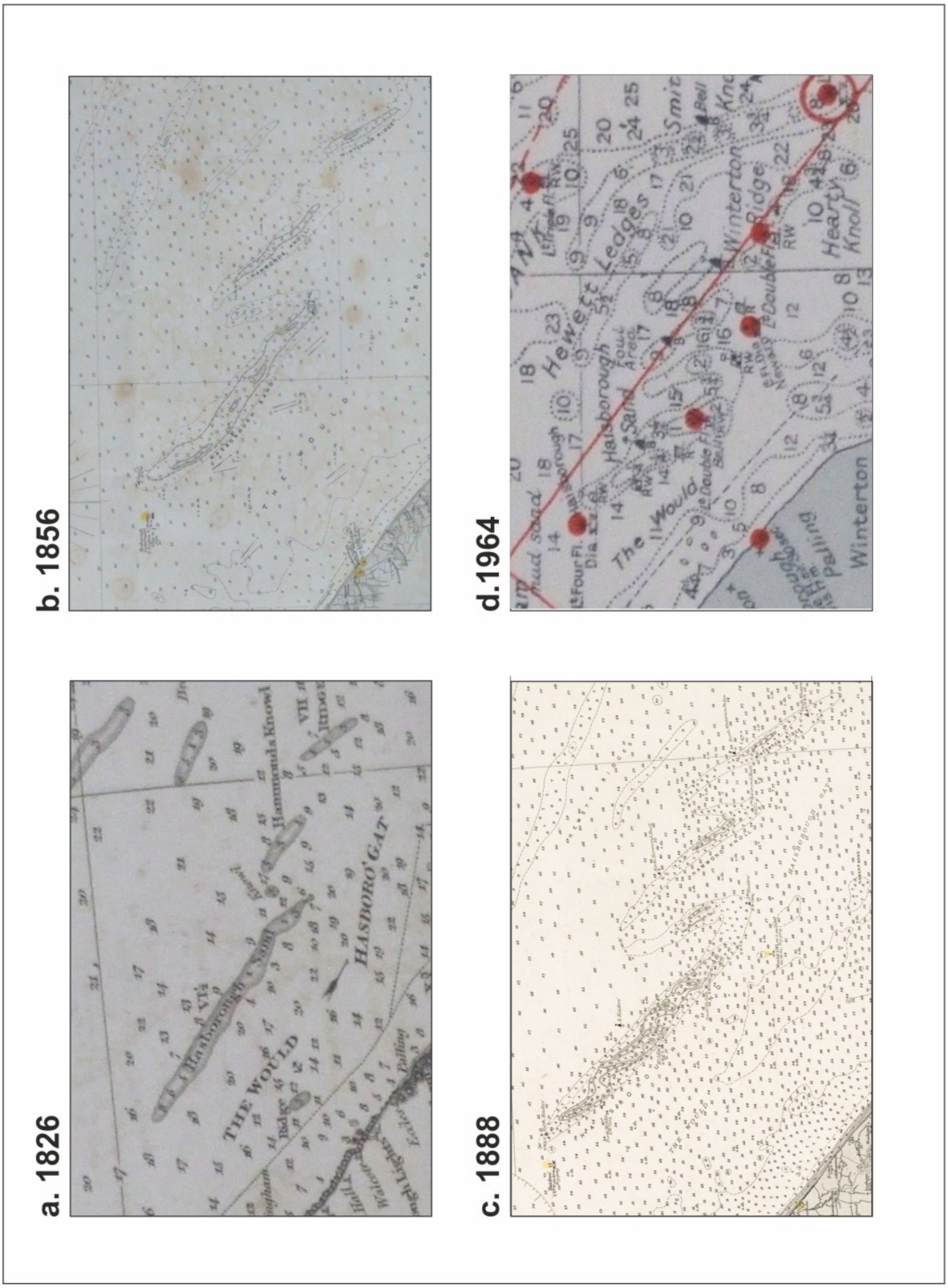

Figure 3.2 A selection of charts showing the same area of seabed through time, demonstrating the changing levels of detail available. Sources: a. 1826 Imray Laurie Norie & Wilson; b. 1856 Admiralty chart (Lowestoft Records Office); c. 1888 Admiralty chart; d. 1964. Imray Laurie Norie & Wilson ‘Blue Black’ fishing chart.

Despite the high-energy environment of the southern North Sea and the effects this may have on the seabed, the locations of favoured fishing grounds have remained relatively static since the industry began (Butcher pers. comm.). On charts, these are generally represented by 'Shoals' and 'Banks', but there are a wide variety of terms used ('shoal' being dialect for a bank) and we can look at their positioning through time to investigate seabed mobility. Some of the difficulties of looking at this accurately are the other things that have progressed through time, the most significant being technologies and our abilities to image the seabed; charts from 1826 are less likely to show a great degree of detail than those from 1964, which display many aspects at once (e.g. Texture and banks, Figure 3.2). Similarly, charts designed specifically for fishing are more likely to show greater detail than those designed purely for navigation. Figure 3.3 shows a series of charts from 1826, 1856, 1888 and 1964. Of these charts the most recent (1964) is the only one designed as a fishing chart. This, combined with its more recent manufacture, does bias it slightly. Its level of detail also makes it difficult to define the edges of named banks from past charts. However, by highlighting banks that are shown in several of the charts it has been possible to look at their movement through time. Figure 3.3 demonstrates that over a period of approximately 140 years there has been little movement of these targeted banks and shoals, with the main difference being the greater amount of detail added to the later maps.

The implications of this is that the fishing grounds being exploited over recent years would have been the same grounds, in approximately the same locations, as those being exploited in the mid-19th Century. Finds recovered in 1880 from the Great Silver Pit, for example, would be from the same location of the Great Silver Pit in 2014. This is supported by recent work on the Outer Thames and Norfolk Banks (Collins *et al.* 1995; Burningham and French 2009), which has demonstrated remarkable stability of broad-scale seabed morphology (i.e. the locations of banks) over the past 180 years and even as far back as the 17th Century.

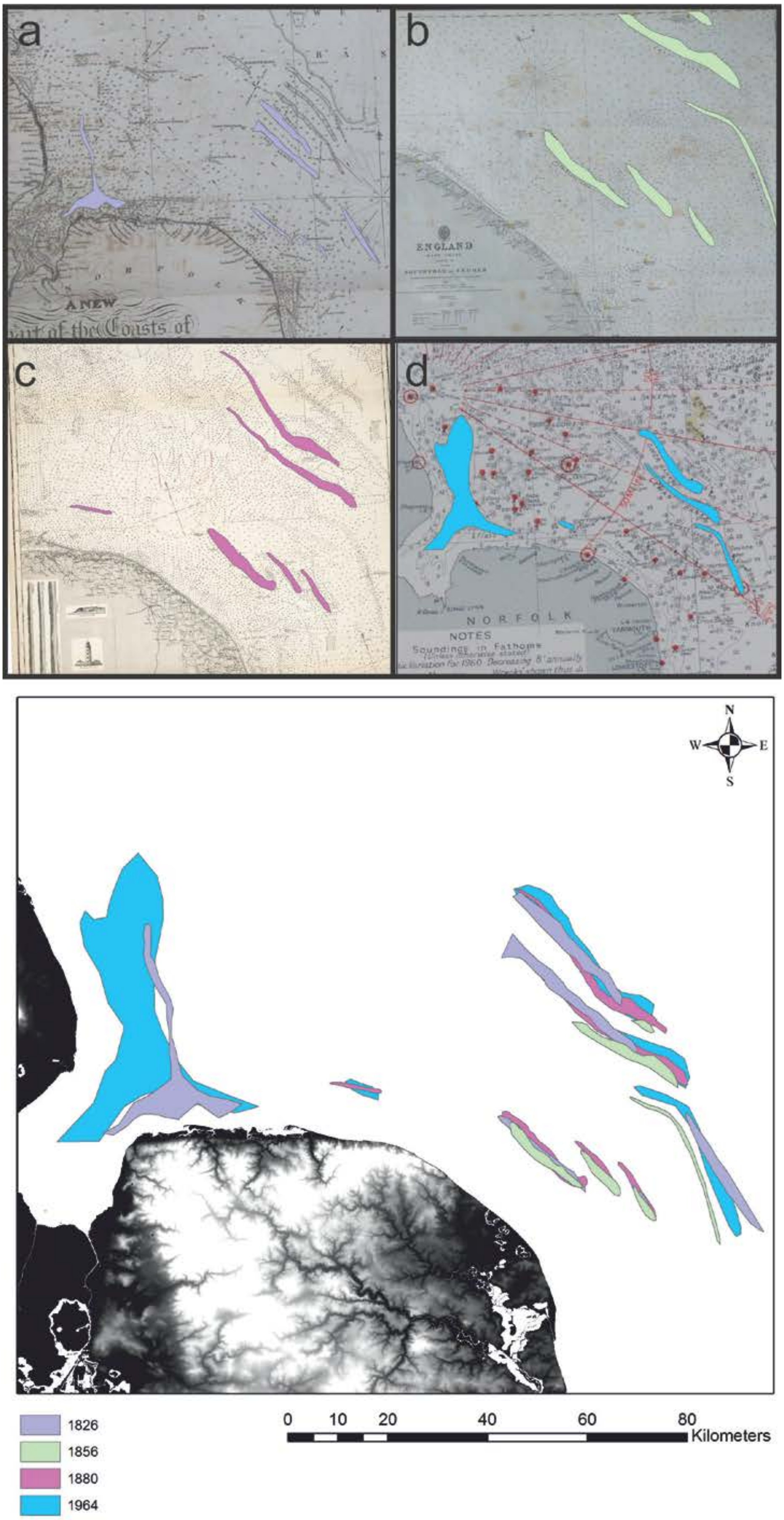
a
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Figure 3.3 Charts showing the locations of mapped banks through time. Chart sources: a. 1826 (Imray, Laurie, Norie and Wilson); b. 1856 (Admiralty Charts; Lowestoft Records Office); c. 1888 (Admiralty Charts); d. 1964 (Imray, Laurie, Norie and Wilson 'Blue Backed' fishing chart).

Given the static nature of these locations, various groups of finds that have been recovered from them can be refined. There are of course some issues with this, since trawlers will occasionally work on an *ad hoc* basis and preference for particular grounds may differ slightly from year to year. When it comes to historic collections, there are no clear and simple answers to these questions, but explicitly building our analysis of them by adding layer on layer of the information that can be gleaned from the record helps to clarify patterning and to highlight avenues of research. This allows areas of higher resolution to emerge and draws out questions that can reasonably be asked of the record.

The locations of favoured fishing grounds have therefore been ascertained for the 19th and 20th Centuries, which allow us to gauge the most likely locations for the sources of the specimens recovered. However, the next step is to refine these further, assigning groups of the material to specific groups of grounds. Using historical sources (e.g. Butcher 1980; Robinson 1996; Smylie 1999), the next section will discuss the methods used in order to determine this next level of detail.

3.2 Territorial trawling locations in the southern North Sea; the development of an industry

The development of certain coastal towns into larger trawling ports forms the basis of the broad locations defined for this research. As with any industry, the fleets and individual owners of the trawlers were in competition to make a profit, and locating and exploiting productive fishing grounds was central to this. So it was not long before territories became annexed by competing groups. Defining these territories allows us to attribute specimens landed at specific locations to a specific area of seabed.

This section will discuss the growth of the trawling industry, providing context for the development of these territories. The main ports of Great Yarmouth and Lowestoft will be introduced, as well as the ports of the northeast, which are important in the industry but have not yielded fossils.

3.2.1 Defining broad seabed areas: The Great Yarmouth and Lowestoft grounds

The practice of trawler fishing has been in existence since at least the 14th Century, when a royal commission under King Edward III (1376/77) prohibited the use of the 'wondyrchoun' (a 10 foot wide beam trawl) then being used in the Thames Estuary and blamed for destroying fish and oyster stocks (Engelhard 2008). Its major expansion into the North Sea however was not seen until much later, in the 19th Century (Butcher 1980; Robinson 1996). This period saw the practice expand rapidly northwards, demand being greatly increased by the industrial revolution and consequent population growth and increasing food requirements (Engelhard 2008).

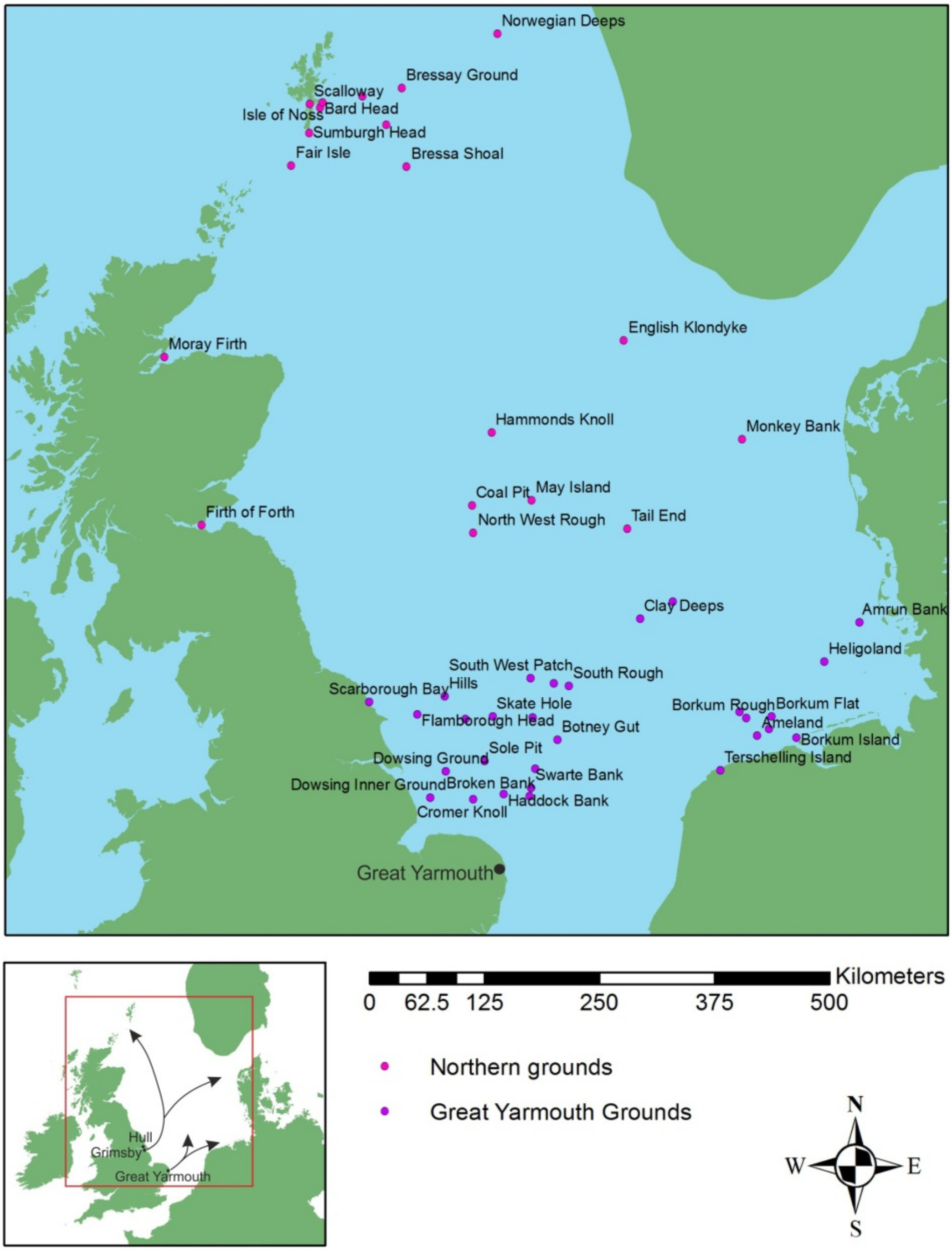


Figure 3.4 Favoured fishing grounds exploited by the Great Yarmouth and North-eastern fleets. Insert shows exploitation patterns and port locations.

Although local, small-scale trawling had been practised previously (e.g. Layton 1827, Section 3.2.2), it was not until the widespread development of the railways from the 1840s on, making feasible the rapid distribution of fish across the country, that it became a dominant, year-round practice in the North Sea (Robinson 1996). The towns of Hull, Scarborough and Grimsby (from 1857) were the main north-eastern ports throughout the 1840s and 1850s, developing large fleets of boats which had moved from more southerly areas and, latterly, from the local population (Robinson 1996, 46), in order to more easily exploit the recently discovered rich fishing grounds of the Dogger Bank and Great Silver Pit (as well as surrounding grounds). The ports of Lowestoft and Great Yarmouth, the most significant ports for this research, were on the increase at a similar time, also aided by the arrival of railways to those towns.

Great Yarmouth grew rapidly in the 1840s and 1850s, most significantly in 1854 under the influence of Samuel Hewett, the owner of a large trawling fleet originally based further south in Barking. Hewett moved to Great Yarmouth, bringing with him 82 trawling vessels in order to gain more rapid access to the Dogger grounds and set up the Hewett Short Blue Fleet (Butcher 1980; Robinson 1996). Although both the north-eastern and the Great Yarmouth fleets were therefore trawling northwards on the Dogger Bank grounds, there were certain differences to their patterns. Whilst there is no accounting for *ad hoc* trawling on the way home, in general the ports of Hull and Grimsby exploited the more northerly grounds of the Dogger Bank such as the Silver Pits, moving further north towards the entrance to the Skagerrak during summer, whereas the Great Yarmouth fleets remained north of the Leman and Ower Banks but never north of 55°N (Figure 3.4).

Lowestoft, although technically a larger trawling town, developed differently from Great Yarmouth and the north-eastern ports. Its railway was built in 1847, facilitating an increase in the size of the catches through their rapid dispersal to consumers across the country (Robinson 1996; Butcher 1980). However, with the Dogger Bank grounds tied up by the Grimsby and Great Yarmouth fleets, the Lowestoft trawlers began to exploit the grounds to the east of East Anglia *"from the Gabbards and Galloper down south, up to the Leman and Ower in the north, and out eastwards to the Brown Ridges"* (Figure 3.5. Butcher 1980, 14; Robinson 1996, 66).

Territories had begun to develop among the trawling communities, and this polarisation is the framework within which the broad seabed locations of finds from certain ports can be distinguished. However, it was not as clear-cut as a series of fleets running identical, but territorial, operations out of a series of different towns. Instead, there are significant differences that become apparent for each of the locations regarding the nature of their businesses and the techniques used. Each of these differences are discussed below, with their implications for the recovery of fossil specimens highlighted for discussion through the results of this research.

3.2.1.1 Fleeting

A method of trawling known as 'fleeting' began to be used in Great Yarmouth as well as out of the north-eastern ports during the 1870s. Fleeting involved spending anywhere from six to eight weeks trawling favoured fishing locations on the Dogger Bank and surrounding areas, employing small cutters to sail precariously back and forth with the catches. Many lives were lost both trawling and whilst transporting catches, especially the hazardous moment of transfer between trawling vessels and small cutters (Butcher 1980). The dangers were more than just from seas and equipment; it was a very tense, difficult life and violence was common: in 1883 it was reported to the House of Commons that ballast stones and firearms were being used by competing fishermen as a result of close proximity leading to the damaging of nets (Hansard 1883; Robinson 1996). There were also the more welcome hazards of 'bumboats' which targeted fishing grounds in international waters, often bartering with alcohol, tobacco and obscene playing cards, the resulting inebriation often leading to drunken, dangerous actions[1] (Higgins 1881; Robinson 1996, 78).

This method of trawling, on a social level, may have a part to play in the perceived patterns of fossil recovery. With Great Yarmouth and the north-eastern towns involved in the method of 'fleeting' and Lowestoft remaining with smaller-scale, shorter-duration trips, could this have had an impact on the trawlermen's desire, ability or willingness to preserve what were sometimes large, heavy fossils?

[1] On a spring day in 1880, the master and a few crew of the Grimsby smack *Cossasck* rowed across to a Dutch vessel, returning with 9 bottles of gin, rum and whisky; by 3pm they were well and truly drunk. As the (sober) helmsman was passing two other smacks, the drunken master attacked him and steered the boat hard to one side. They ran into another smack, causing £40 worth of damage and enraging the master even more who thereupon threatened to sink the smack. He then threw all the fishing equipment overboard, set off all of their signal rockets and rowed away to another boat, never returning (Higgins 1881; Robinson 1996).

3.2.1.2 Ownership

Ownership of fishing boats may also have important implications for any resulting patterns, with a divide in tradition between the north-eastern towns and Great Yarmouth, as against Lowestoft. The fleets from the former towns, being owned predominantly by large companies, were often heavily dependent on mortgaging to buy their fleets of boats, whereas Lowestoft remained dominated by individual ownership (Robinson 1996; Engelhard 2008).

Since the larger companies associated with the north-eastern towns and Great Yarmouth were also those employing the fleeting method, not only would the trawlermen involved with these companies be working under the rules of a larger company, but they would also be working under strained and difficult conditions. The length of time that these fleets were at sea (up to 8 weeks) and the conditions they faced (known as being "sentenced to the Dogger" [Butcher 1980]), do not seem conducive to fossil collection and storage. In contrast the individually owned Lowestoft trawlers, which recovered the bulk of the specimens, remained relatively local, with fishing expeditions that were on average three to ten days long. Of course, the fact that there were fossils collected from Great Yarmouth indicates that this cannot be the sole cause for the discrepancy, but perhaps it played a role.

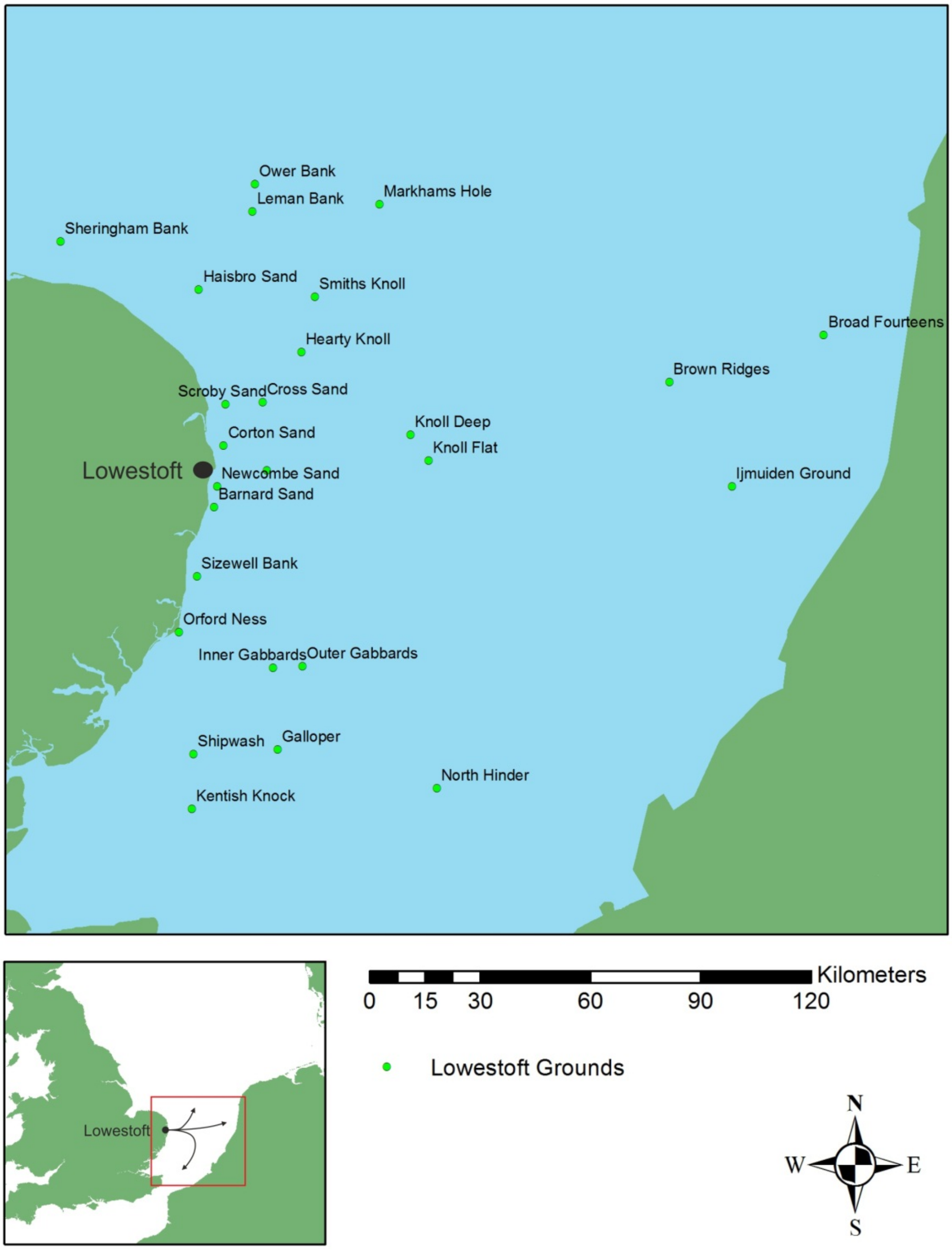


Figure 3.5 Favoured fishing grounds of the Lowestoft trawlers. Insert showing the location of the main map as well as main exploitation patterns.

3.2.1.3 Sailing smacks

Developments in trawler design and the differences in where these technologies were adopted add further information to how and where boats from these ports were trawling, and this can provide additional insights into the recovery of Pleistocene fossils. The main differences were in the design of the trawling gear - otter or beam - and the use of steam versus sail, both of which were intricately linked.

Sailing smacks were the traditional boats used to trawl the southern North Sea in the early days of the industry, and sail provided an effective and long-standing means by which to propel the vessels. However, as with any sailing vessel, this method relied greatly upon weather conditions and provided the trawler with limited power. As such, the distances travelled (especially during rougher winter months) were smaller. For example, the Great Yarmouth sailing smacks worked the Dutch coast from Terschelling to Ameland (Figure 3.6), approximately c.300km away, during the summer months, and the Great Silver Pits and southerly Dogger Grounds during the winter months, c.200km away. The Lowestoft trawlers generally worked closer to home, exploiting grounds such as the Leman and Ower in the north (Figure 3.5, c. 50km away) and Gabbards and Galloper in the south (c.50km away) during winter months, and over towards the Dutch coast on, for example, the Brown Bank during the summer (c.100km away). The differences between the two ports may be attributable to the fleeting method operated out of Great Yarmouth, which allowed trawlers to operate at greater distances for longer, as they did not have to make constant return journeys with their catches (Section 3.2.1.1; Robinson 1996, 71).

3.2.1.4 Steam power

The large-scale introduction of steam-trawling in the 1880s meant a step-change in the productivity of these boats; they could travel further, reach greater depths and all for a longer time (Robinson 1996, 105). However, this practice was not adopted everywhere and in many ports trawler fishing remained on a relatively small scale throughout the 19th Century. Lowestoft and Great Yarmouth were two of these areas and despite having impressively large fleets of trawlers (Lowestoft had approximately 300 throughout the 19th and early 20th Centuries) remained predominantly sail-powered, and therefore relatively restricted spatially (Butcher 1980; Robinson 1996).

By 1900 the north-eastern ports had moved almost entirely to steam power, and with the discrepancies this presented between the capabilities of Great Yarmouth and the steam-powered trawlers, both exploiting the Dogger Grounds, the Great Yarmouth fleets were struggling to compete. The explosion that this new technology saw in the numbers of trawlers had a knock-on effect on the productivity of the trade; the numbers of trawlers in the North Sea throughout the 1890s increased by 250% but each catch fell by nearly a half (Garstang 1900). As a result, many of the steam-powered north-eastern fleets began to move further afield and the 20th Century saw the move towards the exploitation of distant fishing grounds such as the Barents Sea and the Greenland coasts (Robinson 1996, 111).

In terms of modern trawling, the industry has changed dramatically since the 19th and early 20th Centuries, with resulting changes to the patterns of trawling grounds. World War 2 marked the end of commercial sail-trawling and, in order to meet the previous levels of catch, distant grounds became the dominant source (e.g. Greenland coast, Iceland grounds), working from the towns of Grimsby and Hull (Figure 3.4). Of course, trawling still persists today in the southern North Sea but only at a far smaller scale and with far more restrictions (e.g. Common Fisheries Policy 1970; 1983; 1992; 1995); the practice of collecting has also declined. But this does not mean that trawlers no longer recover fossils: in fact the Dutch trawlers, who still have a relatively strong industry (Glimmerveen *et al.* 2004; Mol *et al.* 2006), regularly trawl bones from the Dogger Bank and Brown Bank (Figure 1.2), and supply many of the fossil shops throughout Britain. More positively, for this research, there are active trawlers working on a small scale and bringing this material up as an interesting – and profitable - by-product of their trade. An example of this from the coast of Essex will be discussed in detail in Chapter Five.

3.2.1.5 Trawl design

Along with the increased power that steam technology gave the trawling industry, new types of trawler design were being developed. The technique of beam trawling had been the traditional method, whereby a long wooden beam, often made of elm, was held a couple of feet above the seabed by two riders, which were attached to a line of weights that would drag along the seabed, drawing bottom-dwelling fish into the nets (Figure 3.6). These weights, which held one edge of the net, were often attached to teeth designed to dig further into the seabed and bring up oysters, scallops and other kinds of molluscs. Depending on the type of seabed sediment, these weights and added teeth could have quite a significant effect on the seabed surface, remodelling the landscape of the sea floor (Løkkeborg 2005). However, the design of the otter trawl (Figure 3.6), first mentioned in 1880s but with usage properly starting from 1895, proved a more effective method of catching fish (Robinson 1996, 112). The otter trawl, instead of relying on a wooden beam, uses two 'otter boards', one at each end of the net mouth, which are positioned so that when dragged through the water they are forced outwards, which prevents the mouth of the net from closing. A lighter weighted rope, relative to beam trawling, is used to keep the bottom edge of the mouth of the net in contact with the seabed and is therefore less destructive than those associated with beam trawls. The only parts of an otter trawl that are more destructive are the otter boards, which can dig up to 20cm into the seabed (*ibid.*).

Otter trawling therefore seems less likely to disturb seabed sediments enough to recover fossil specimens, unless at the point of the otter boards. It was also a technique that was most effective when applied by steam trawlers and the otter trawl became synonymous with its use. The adoption of steamers in the north-east, therefore, also saw the predominant use of otter trawl technology, with those working out of Lowestoft and Great Yarmouth retaining the beam trawl, sailing method. Despite the Lowestoft trawlers' making this pattern work until 1939, the Great Yarmouth fleet was eventually out-competed by its steam-trawling competitors from the north-eastern ports. Its major operations ceased in 1901 when the Hewett Short Blue Fleet ceased business, leaving only a few local trawlers working (Butcher 1980, 15).

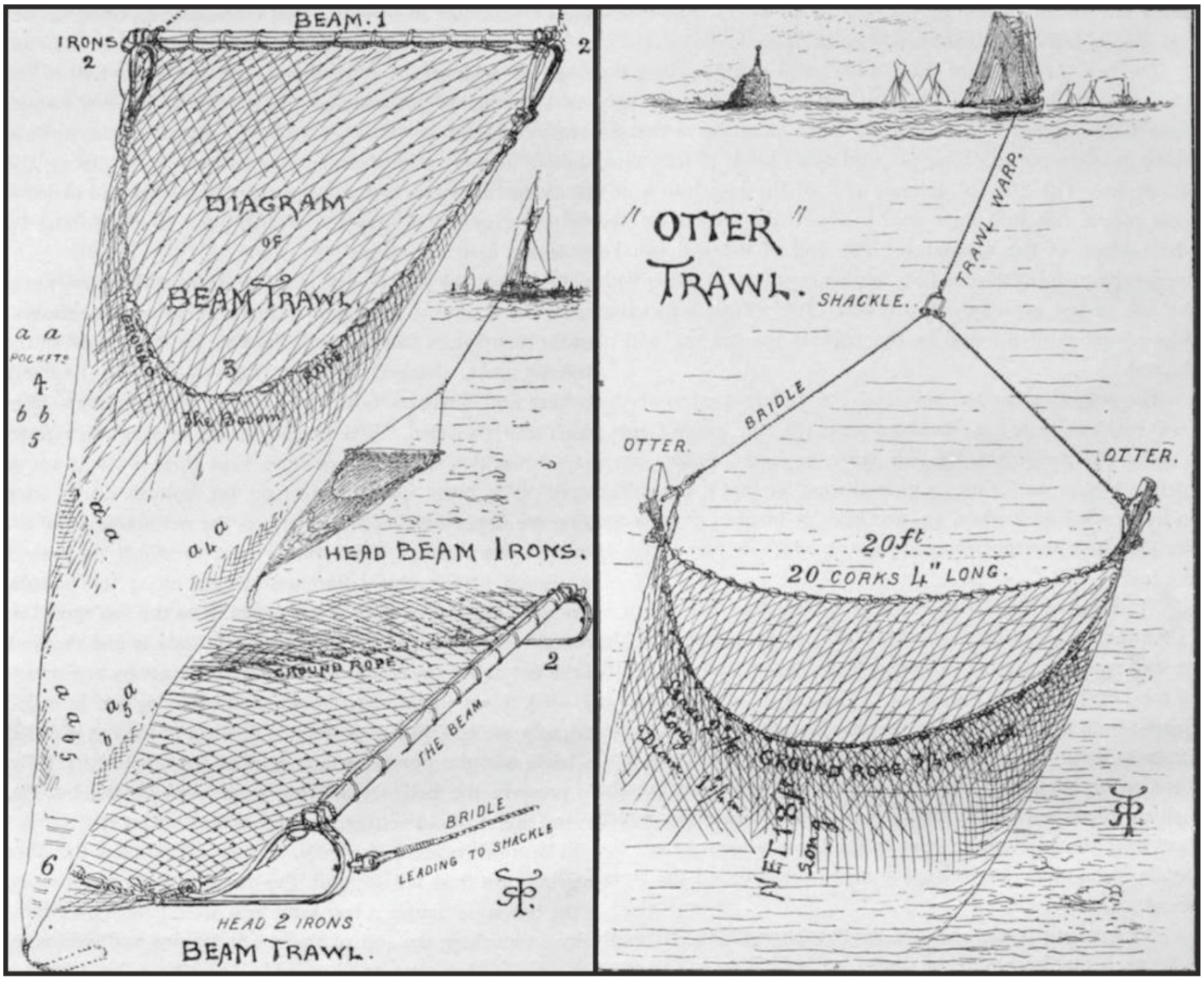


Figure 3.6 Images of Beam and Otter trawl (Source: Bickerdyke 1895)

From a practical perspective, these distinctions in trawling methods between the north-eastern ports, Great Yarmouth and Lowestoft may have important implications for the patterning of the recovery of specimens.

With the beam trawls having a more widespread destructive effect on the seabed, it would make sense to expect a higher volume of specimens to be recovered when they are used. Given their more prolific and longer-term use from the harbours of Lowestoft and Great Yarmouth, we should therefore expect these areas to have the highest volumes of specimens. However, although this might be a pattern to expect for periods after the adoption of steam and otter trawling, there are three decades between the development of these areas as at least seasonal trawling towns and the beginning of steam-powered trawling. It would therefore seem reasonable to expect three decades of fossil recovery from these north-eastern towns.

3.2.1.6 Seasonal territories

Trawling in the southern North Sea was heavily seasonal, with the Dogger Bank grounds, such as the Silver Pits and Botney Gut (at the southern extent) being worked by the north-eastern fleets during the cold winter months when dover sole sought refuge in deeper waters (Butcher 1985) and the weather made further travel dangerous (Robinson 1996, 66). The grounds north of Heligoland (near the Dutch coast), over to Horn Reef and Amrun Ground and up to the Little Fisher Bank near the entrance to Skaggerack were exploited during the calmer spring and summer months (*ibid.*).

Sticking well south of 55°, the Lowestoft fleets tended to be able to work their grounds all year round, exploiting those such as the Gallopers and Gabbards for their dover sole during the winter months. The dover sole was a highly valued and could be caught at various locations throughout the seasons, generally preferring a muddy or sandy seabed. It may also be significant that a heavy ground-rope was required to drag the bottom properly to catch these favourite fish, with chains often wrapped around the trawl gear and a slow and steady towing speed. With the increased destructive effect that this would have had on the seabed, would this have had implications for fossil displacement and recovery? Oral histories from trawlermen who worked in the southern North Sea claim that it was the sailing smacks with their beam trawls (technologies which persisted in Lowestoft and Great Yarmouth, but were replaced by steam and otter trawls in the north-east [Section 3.2.1.4/5]) that were most successful with this method, perhaps providing another reason why it was at these East Anglian ports that the fossils were predominantly brought in.

Another factor in the recovery of specific fish species, as well as fossil material, is mesh size. Fishing for species like dover sole requires a smaller mesh net (approximately 78mm), whereas when fishing for pelagic species, such as cod or haddock, a larger mesh of approximately 120mm is used (Brand pers. comm.). Of course, when recovering mammoth bones it is unlikely that any mesh size would be too large, but the smaller sizes would certainly aid in the recovery of smaller species such as bovids and cervids. Another important factor is that dover soles prefer mud bottoms; the combination of soft seabed, allowing the trawl to sink far deeper, with small mesh sizes would certainly increase the chances of fossil recovery from these areas.

Knowing where the ‘fossil- trawlers’ were working at points throughout the year as well as what they were fishing for could, through seabed preferences, allow a correlation of seabed deposits with recovered bones. Although oral sources report that dover sole and plaice were the main species being sought by trawlers (especially beam trawlers, with the later otter trawlers also catching pelagic fish such as cod and haddock [Butcher 1985, 82]), the coarseness of the data regarding individual trawlers is such that linking any specific boat to any fossil assemblages, or with any specific fish species that they may have been trawling for while the fossils were recovered, is simply not possible. Unfortunately, this also extends to the seasonality of fishing grounds, so whilst it is possible to refine the areas of seabed being exploited at various parts of the year, this cannot be linked to fossil recovery. Broad patterns of favoured grounds must therefore be used to define various regions in the southern North Sea that were being exploited by trawlers from each port.

Summary

The ability to distinguish between the development of the main ports and the seabed territories that they exploited allows us to further refine the original favoured grounds into separate groups:

- Lowestoft Grounds (Figure 3.5)
- Great Yarmouth Grounds (Figure 3.4)
- North-eastern Grounds (Figure 3.4)

The differential development of these industries may have a significant impact on the recovery of fossils throughout the period in question and provides the historical resource with another level of context, further refining their implications for Palaeolithic deposits.

3.2.2 Small-scale trawling along the coastal strip

The development of these large ports and the information it provides for us about trawling locations is not the only pattern of exploitation seen, there was also trawling closer to land. Fishing from villages such as Happisburgh would have been on a far more local scale, launching from beaches (Figure 3.7). The boats would have been smaller and with reduced ranges; almost certainly sail-powered and not leaving sight of the coastline (i.e. within a couple of kilometres [Smylie 1999]). Exploiting resources closer to shore, and with no formalised large-scale fishing port to work from, this may be a largely invisible activity, seen only through oral histories and written sources that refer to specimens being recovered from these areas (e.g. Layton 1827).

Figure 3.7 Southwold beach at around the turn of the 20^{th} Century showing typical beach punts above the tide line (from Smylie 1999)

An example of this kind of 'invisible' trawling can be seen through the publications of Clement Reid and Reverend James Layton. The 1820s saw the discovery of a bed of oysters off the coast of Happisburgh which was exhaustively trawled until the oysters were eradicated only four years later (Layton 1827). Within these four years Rev. James Layton, who lived locally in Catford, recovered and collected many fossil specimens (Layton 1827; Reid 1890). These fossils, many of which are still held in the Natural History Museum, London, are predominantly of the early Pleistocene species *Mammuthus meridionalis*, and come from an unusually discrete area of seabed '*about three-quarters of a mile from the shore, opposite Happisburgh*' (Reid 1890, 174).

This type of trawling can be inferred from specimens that cite a smaller location, such as Happisburgh or Sea Palling, as their landing location. There is of course an alternative possibility, which is that larger trawlers provided the collector with an area of land they were trawling by when the specimen was recovered. This seems relatively unlikely, given the vast majority of finds stating their landing port location, but is certainly possible. However, the implications are not negative: the assumption that smaller-scale trawling took place in close proximity to (within sight of) the coastline realistically places them within a few miles of shore. Similarly, for a larger trawler (operating from one of the main ports) to provide an accurate location of the small town/village that they were trawling off when they recovered a fossil implies that they were in sight of this location and that the shore was their most immediate reference point. In each case, the deposits being indirectly exploited would be within the same coastal strip.

The specimens recovered from these smaller-scale or shoreward locations, may provide higher-resolution patterns and will be discussed separately within the succeeding chapters.

3.2.3 Summary

This section has demonstrated how, through the use of historical sources, favoured fishing locations for the 19th and 20th Centuries can be refined into territories that relate back to the home ports from which the trawlers worked. It is clear that there were significant differences between the north-eastern ports and those of Great Yarmouth and Lowestoft in terms of their social approaches to trawling as well as their methods used. Whether these factors will have implications for the geographic patterning of the recovery of fossil specimens will be addressed in the following sections.

3.3 Locating collections

Having discussed historical methods for refining the locations of groups of finds, this section will present the data that has been collated for this research. Since they form the majority of the record it will concentrate on the historic specimens, but will also include the finds that have been collected from the seabed in recent years. There are therefore distinctions made between the 'historic collections' (those deposited in museums by collectors before 1970), the 'modern collection' (collected since 1970) and the 'entire collection' (which includes the specimens collected over recent years by modern trawlers and aggregate dredgers as well as the historic specimens).

With this research concentrating on the southern North Sea, seventeen county museums' services and town museums from along the East Coast (and one in Dublin) were contacted regarding dredged material within their collections. The large collections held by the Natural History Museum (NHM) (n=339), London, the Norwich Castle Museum (n=263) and Colchester Museums Service (n=342) have been collated, with smaller collections from Dublin and Ipswich added remotely. None of the remaining museums was aware of any relevant information in its collections. The online resources of the Portable Antiquities Scheme (PAS) and county Historic Environment Records (HERs) were also consulted (Figure 3.8).

The introduction of the British Marine Aggregate Producers Association protocol for reporting archaeological finds (in association with English Heritage and Wessex Archaeology) has also meant an increase in finds being reported over recent years (Figure 3.9), with these being from aggregate dredging as opposed to trawling. Because of the legislation and restrictions on where aggregate dredging can take place, these activities are spatially well-constrained, resulting in an increased chance that the finds can be located accurately on the seabed (e.g. Area 240). Importantly, and in contrast with the lithics recovered through the aggregate industry, the bones reported to BMAPA are recovered on board before landing and crushing, as they are conspicuous among the aggregate.

Museum / county service contacted	Details
Aberdeen	None
Tyne and Wear	None
North Lincolnshire	None
Hull	None
Yorkshire (York)	None
East Riding, Yorkshire	None
Scarborough	None
Whitby	None
Lincolnshire	None
Hartlepool	None
NHM, Dublin	14
Norwich Castle Museum	263 (dominated by 19th century specimens)
Colchester Museums Service	342 (recently recovered)
Ipswich Museum	22
Southend-on-Sea	None
NHM, London	339 specimens (dominated by 19th century)
Kent	None
PAS	None
HER	Only BMAPA material from Area 240
BMAPA	139 specimens (since 2005)

Figure 3.8 Map showing locations of museums and museums services, with table showing those that have trawled specimens.

The accuracy of this process relies on when and where the specimen is found. The ships will dredge the seabed until they are fully loaded, which may mean only one length of a licensed zone (c.3km), or several (Bellamy pers. comm.). The important point is that since this information is logged, any finds that come out of a dredging expedition can, in theory, be pinned down to a known area. In reality, the majority of the records simply state which licensed zone the find is from, but the potential is there, as has been demonstrated by Area 240 (Russell and Tizzard 2011). To date, approximately 139 faunal specimens have been recovered through this process.

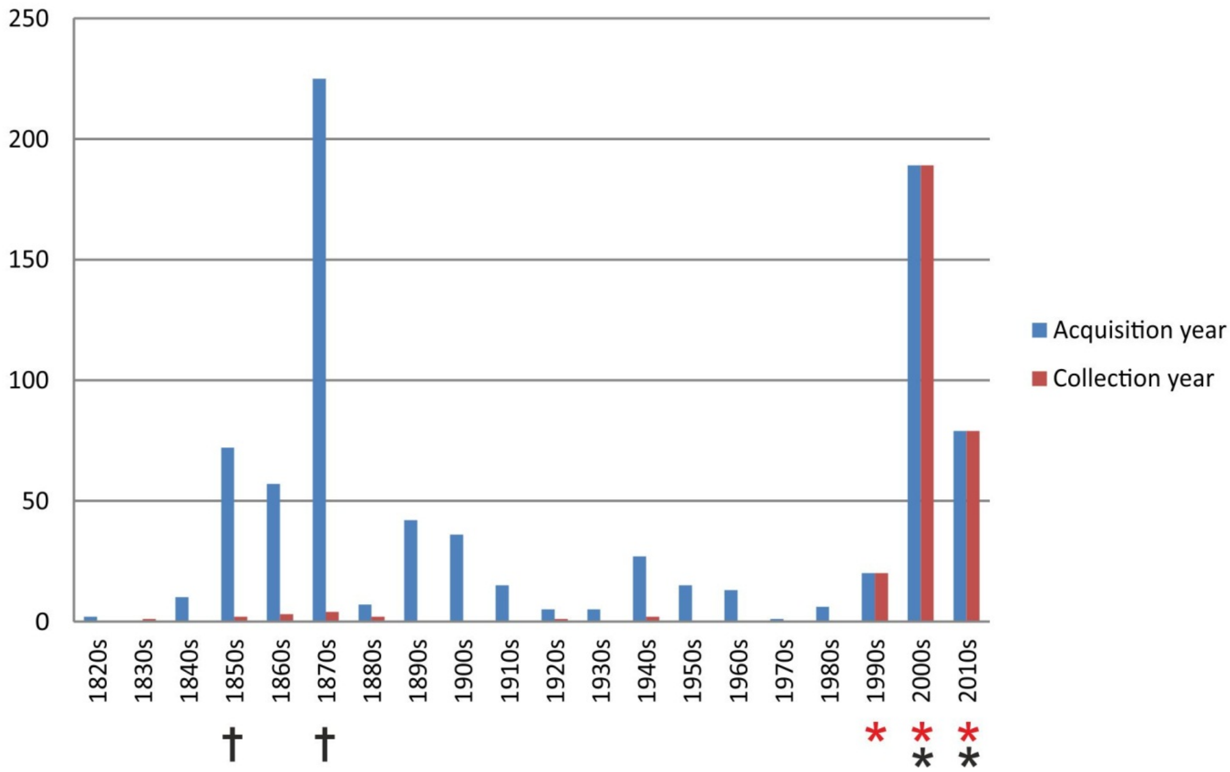


Figure 3.9 Frequency of finds per decade. The acquisition data, showing when the specimens were acquired by the museums, is shown in blue. The collection year data (where available), showing when the specimens were recovered from the seabed, is shown in red. † indicates a year where a major collector has died. Red asterixes represent decades that include recently trawled collections and black asterixes represent the inclusion of aggregate (BMAPA) data.

In terms of the historic collections, it became apparent through discussions with museums that the smaller, local museums generally do not keep un-exhibited material on site, but that this is stored by more centralised museums' services. The museums that were individually contacted were singled out because they had a specifically maritime theme, and often at the suggestion of a larger museums' service, such as Aberdeen Maritime Museum. The exceptions are museums such as the Norwich Castle Museum and the Natural History Museum, which are not museums' services but retain large collections from their respective counties within their storage facilities. Perhaps for these reasons, the distribution of material does not always appear to be directly linked with where the antiquarians lived, although it is usually in relatively close proximity. We know that the Reverend James Layton collected mostly in Happisburgh while living at Catfield, Norfolk, but his collection is held by the Natural History Museum in London. However, when he died in 1859 he was living in Sandwich, Kent, so the NHM was relatively close; it was (and is) also one of the most prominent museums of natural history, which makes it an obvious place for the specimens to be donated or sold to. The fact that there is southern North Sea material located at the NHM in Dublin further indicates that specimens have not always ended up close to where they were recovered; a publication from the New York Times (1907) describes an auction of a 'James Backhouse' collection in London, with specimens being dispersed globally (including to Dublin) as a result.

Given the prolific 19th Century trawling trade which developed out of the north-eastern towns of Hull and Grimsby (Section 3.2, Butcher 1980; Robinson 1996), it is surprising that no records of trawled remains have been found at these locations. Reasons for this are not clear, but could include a lack of collectors, the collections having been lost within vast stores of acquisitions, or the style of trawling that developed in these areas. This will be discussed further in Section 3.5. Museums from this area have, however, recorded fossil material that is pre-Quaternary, perhaps relating to the more northerly grounds that were exploited by fleets from these areas in the late 19th and early 20th Centuries (Figure 3.4; Robinson 1996, 110). These areas were further north than the formation, or outcropping, of terrestrial Pleistocene deposits. In keeping with the historic evidence, the main towns represented by trawled remains are stated as Lowestoft and Great Yarmouth, as well as a significant collection from Happisburgh. These collections have almost entirely ended up in either the Natural History Museum, London, the Norwich Castle Museum or Colchester Museums Service.

3.3.1 Method of collation

The collections that have been identified are unsearchable to researchers as they do not exist on any external databases (the exception being the PAS, as well as an internal database that exists at the Norwich Castle Museum but which cannot be externally interrogated). They therefore had to be identified through discussions with the museums' curators and visits to museums' stores.

Once located, the available specimens from each museum were then photographed, recorded and entered onto a working database (see Appendix CD). The Norwich Castle Museum has computerised acquisitions and so the information could be extracted from this, worked through for relevant information and added to the database. This collation therefore brings together for the first time the existing UK offshore resource from the southern North Sea, allowing it to be quantified and the distribution and patterning of the specimens analysed.

In addition to the rows of specimens, the original acquisition registers were extremely useful for finding extra information about collectors and years of acquisition (Figure 3.10). They also revealed the amount of specimens that are missing from the physical collections that had once been acquired; the Owles collection, for example, is missing 119 specimens. Although this is by no means ideal, the detail in the acquisitions registers first helped to identify the specimens and then provided information, allowing the record of the specimens' species and location to be used.

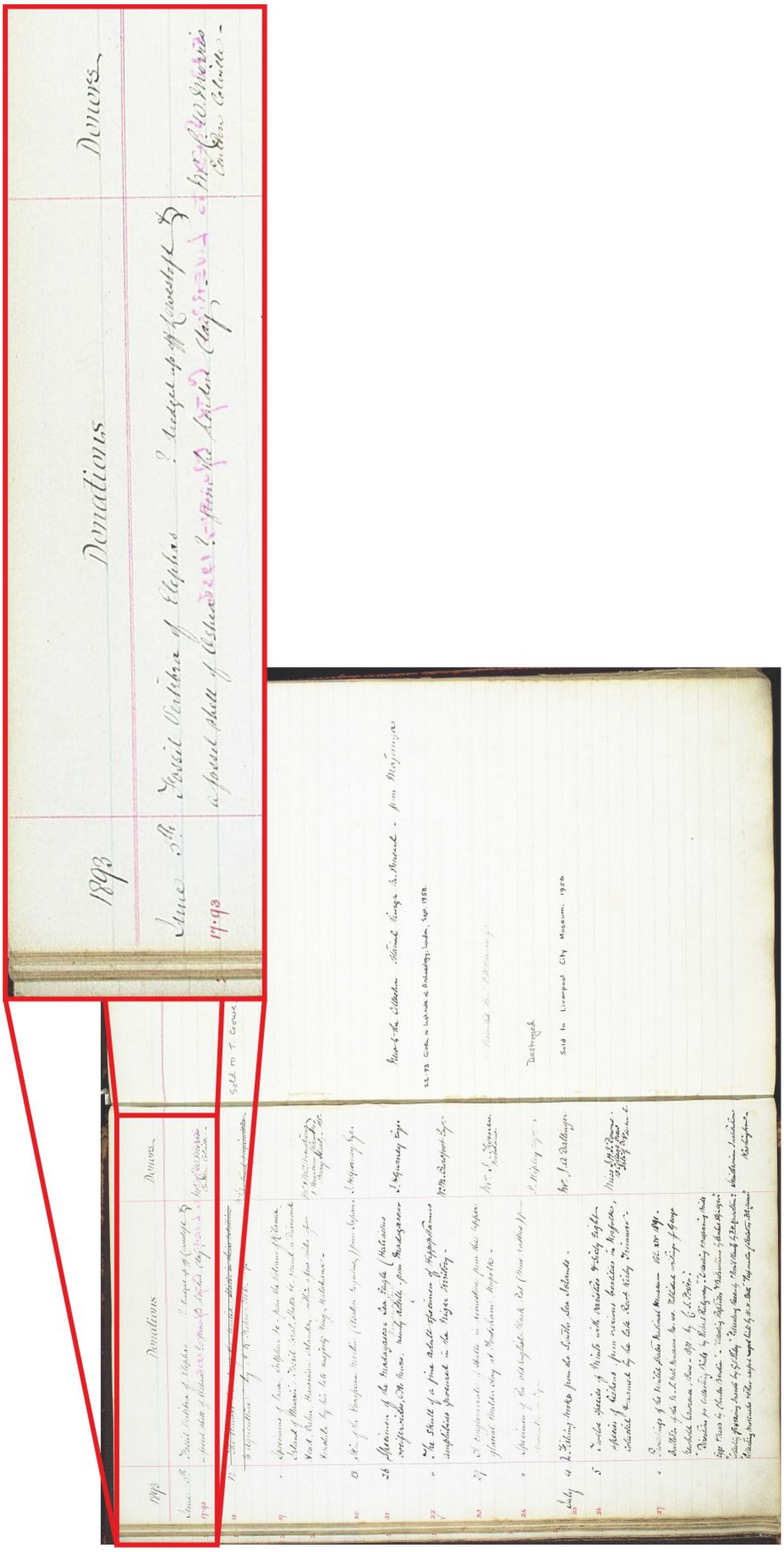


Figure 3.10 An example of an acquisition register (NCM)

In total, 1,119 specimens were recorded, with all but 139 (BMAPA) derived from trawling. Of these, 76% (n=741) are historic, with the remaining 24% (n=239) modern specimens, having been recovered since the 1970s. Although these are considered as a whole, the modern material is important for two reasons. First, the locational information is far more precise and so whilst the methods adopted for discussing the historic patterning are not necessary for these specimens, they add an interesting component for assessing the strength of the identified historic patterns. Secondly, they demonstrate that, although the seabed in the southern North Sea has been extensively trawled and commercially worked, there are still Palaeolithic deposits yielding faunal material: a point returned to in Section 3.5.

There were eighteen locations recorded for the specimens, which range from 'North Sea' to 'Happisburgh': extremely broad to very local. Recording the accurate species identification of the specimens was extremely important, as understanding the evolution of taxonomic lineages has implications for the environments we recognise as well as date-ranges represented by the parent deposits, as species evolve and become extinct in certain areas at certain times. Groups of fauna also imply climatic conditions. For example a cold stage fauna would typically include *Mammuthus primigenius* (woolly mammoth) and *Rangifer tarandus* (reindeer), whereas warmer conditions would be indicated by *Palaeoloxodon antiquus* (straight-tusked elephant) and *hippopotamus*. Correct identification of the faunal material from the submerged zone is therefore crucial for recognising patterning, potentially telling us the broad periods that their parent deposits date from. However, despite many of the collectors being avid natural historians and spending their lives working on material of this kind, much has changed over the past few centuries as regards knowledge about the evolution of these lineages. For example, we now know that there are several pre-Elsterian Rhinoceros species within these collections, previously all identified as *Rhinoceros etruscus* (which is now believed to have lived much earlier [Breda *et al.* 2010]). Similarly, with mammoth teeth being some of the most prevalent fossils, their identification has the potential to yield a lot of information. However, one mammoth species *Mammuthus trogontherii* (steppe mammoth), contemporary with the earliest occupation of this area, was not discovered until 1885 (Maglio 1973). It is therefore possible that specimens identified as the earlier species, *Mammuthus meridionalis* (southern mammoth), are in fact *Mammuthus trogontherii* (steppe mammoth) and that significant patterns are being missed. In this case, where elements are identifiable to species level (teeth and whole elements in particular), further work will be carried out to ensure their correct identification.

Further details available for these records include who the collector was, the acquisition (if not collection) year (Figure 3.9), species and element (if identifiable) and location. The accuracy of this information varies and in some cases has been altered from the original description or is entirely absent (Figure 3.11). To supplement the metadata acquired from the museum's acquisitions registers and on the specimen's labels, collectors' diaries or catalogues were searched for. Unfortunately they were not found, and in many cases may not have existed, but some important information was gleaned from letters written and published by various collectors (e.g. Layton 1827; Woodward 1891). Furthermore, indirect information such as where the collectors lived, worked and collected has been used to infer how and where they were collecting their artefacts (Section 3.4).

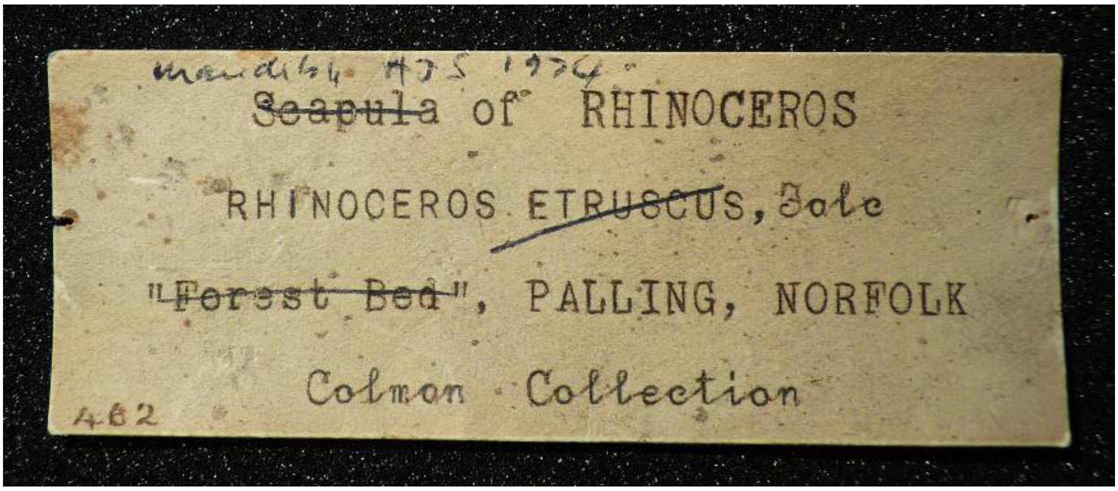


Figure 3.11 Specimen's label showing the amount it has been changed since acquisition (Source: Simon Parfitt)

Locating and collating the material from these museums was not a straightforward process. Many museums were unsure whether they held any collections and of the associated information. Moreover, once identified, the entire collections had to be retrieved from storage, laid out and analysed, sometimes for the first time. This is therefore the first time that all this information has been brought together and evaluated; an important first step allowing us, through metadata, to link it back in with the historic record and to begin characterising the submerged resource.

3.4 Antiquarians

The link between fossils being recovered by trawlers and their ending up in museums' stores lies with their collection and curation by antiquarians and collectors throughout the 19th and 20th Centuries. This section will look at who they were, where they lived and how this may relate to the patterns of fossil collection which have been made apparent throughout this chapter as well as those that become apparent through the results (Chapter Four).

3.4.1 Who were they?

The collecting mania that was such an essential feature of the 19th Century in Britain drove many enquiring minds into quests for knowledge about the development of our natural world, especially since this was a period of great religious turmoil (McNabb 2012). Antiquarians avidly collected all kinds of curiosities, and with the coincident increase in trawler fishing a wealth of Pleistocene fossil material was made available. In a similar fashion to the handaxe collectors of the terrestrial gravel pits (see Hosfield 1999), antiquarians would purchase fossils from trawlermen to add to their collections. Of course, this method of collection may add a certain bias to the material: handaxes over flakes in the former, and distinctive, intact bones over smaller elements in the latter. However, what is arguably more important in the case of faunal remains is simply the ability to identify the presence or absence of particular species (or even that the bones exist at all) and with many hundreds of these fossil remains now curated within museums across the country they will form a significant part of this thesis.

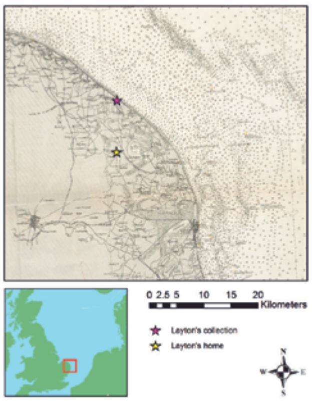
There are 63 named collectors responsible for the collection of the trawled specimens in the database developed for this thesis. However, the majority of the collection can be attributed to five people: Reverend James Layton, Reverend John Gunn, John Owles, J.J. Coleman and Les Brand (a modern collector). These antiquarians were well off and well educated (see text boxes): clergymen (James Layton, John Gunn), businessmen (J.J. Colman) and magistrates (John Owles). Their interests were diverse and they were often collectors of many kinds of curiosities (for example J.J. Colman collected many anthropological finds as well as a library of historical documents and John Owles had a large collection of porcelain [www.greatyarmouthhistory.com]).

The majority of the collectors, and certainly those mentioned above, lived in close proximity to the East Anglian coastline. The richness of this coastline, and indeed region, is likely to have its roots in the preservation of Quaternary deposits, capped by the Elsterian till, as well as the prevalence of quarries in this flint-rich area (e.g. Ashton and Lewis 2002; Ashton *et al.* 2011), facilitating the disturbance and recovery of Pleistocene material. Given the renowned Quaternary deposits along the coastline of this area, it is not a surprise that these people had their interest sparked by the bones and plant remains eroding from their local coasts (see Reid 1890), and a history of collection in this area is well documented. It is also clear that several of these collectors were contemporaries and had often learnt from or acted as mentors to other natural historians (e.g. Text Box 5).

The fact that these collectors were also drawn to the faunal remains brought in by the local trawlers is not surprising, and the rapid development of the trawling industry in this area throughout the middle to late 19th Century would have provided ample opportunity for this. The development of Lowestoft and Great Yarmouth, two of the most prolific ports for the landing of these fossils, was clearly taken advantage of by local collectors. But what was it that drove this abundance of fossil material? The development of trawling communities further to the north-east in Grimsby and Hull should surely be reflected by collections from these areas, but this appears not to be the case (Figure 3.8). Alternatively, was it the areas of seabed these trawlers were exploiting, the social conditions on board various vessels and within companies, or are we simply missing evidence? These questions will be explored further within Section 3.5.

Text Box 5: Antiquarian Biopics

Reverend James Layton



Location of Layton's home until 1831 and area of his main collection

Reverend James Layton was born in 1780 in Norfolk to parents Nicholas and Hannah Layton. He attended Eton until 1798 when he went on to study at Corpus Christi College, Cambridge graduating in 1802 when he was ordained as a deacon in Norwich, being made a priest in 1806. In 1817 he married Lydia Roach in Norwich and at some point before this time had been made Rector at Catfield, approximately seven miles south of Happisburgh. He stayed at Catfield until 1831, when he moved south to be rector of Sandwich St. Peter in Kent for five years. He remained in this area until 1854, when he retired to Swinbrook parsonage, near Oxford, where he died on 26th August 1859 aged 79.

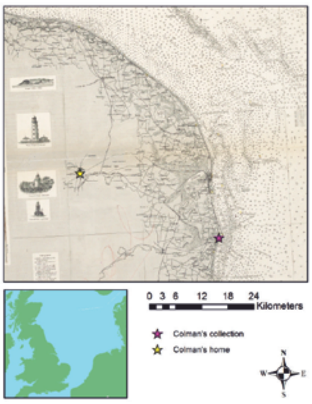
Layton was clearly born into a relatively wealthy family and was well educated, attending Eton and going to University. Being a priest he would also have had time for reading, writing letters and publications (eg. Layton 1827) and exploring his interests, which in his case were natural history and geology. He formed great friendships with a number of influential antiquarians of his time, Dawson Turner of Great Yarmouth, a banker but "...scholar at heart..." (Dawson 1961, 232), as well as Charles William Peach, a geologist whose early career Layton played an important role in.

According to Chambers (1829, 129) Layton owned "...the finest collection of mammal remains from the Norfolk coast..." most of which were collected from oyster dredgers off Happisburgh (Layton 1827, 199; Reid 1890, 174) and represent early-Middle Pleistocene species collected via small-scale, local trawling (Section 3.2.3.3). His collection was donated to the British Museum (Natural History [now Natural History Museum]) in 1858, a year before his death. The reasons behind this are speculation, but given his life-long interests in the subject he may have been keen that this collection be put to use for further research after his death.

Jeremiah James Colman

J.J.Colman (www.findagrave.com)

Jeremiah James Colman was born in 1830 in Norwich, the third member of the family in charge of the famous Colman's company. Although there are no specific publications relating to his collection of fossil material from offshore, his large collections of historical documents and paintings are well known (Norfolk Heritage Centre [Norfolk.gov.uk]). Colman was a philanthropist and his collections were for public good and personal interest; in contrast to the above collectors he was not a natural historian.



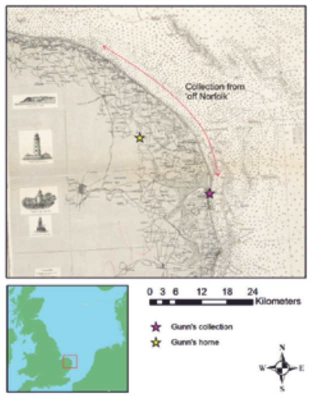
Location of Colman's home and location of his main collection

Colman's collection was donated to Norwich and Norfolk museum in 1877, the year before he began to build-up his vast library collection. The two may be linked, perhaps indicating his changing interests or priorities, but it is not possible to be sure. Colman died in 1898 but, thankfully, his business continued.

The majority of Colman's collection was collected from Lowestoft or Southwold, with some coming from simply 'off Norfolk'. Given the types of grounds being exploited (Section 3.2.3) it is not surprising that the majority of the specimens are Middle - Late Pleistocene species such as woolly mammoth.

Text Box 5: Antiquarian Biopics

Reverend John Gunn



Location of Gunn's home and his collections

John Gunn is one of the better known antiquaries of the time, although his fame mostly comes about through the (acknowledged) work of others; he had no great eagerness to publish.

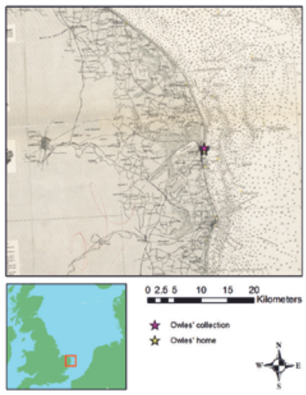
Born in 1801 to a life in the Rectory in Irstead, Norfolk (his father, William Gunn, was the Rector, as was he from the year 1841), Gunn grew up surrounded by historical and archaeological books and curiosities (Geological Magazine 1890, 331). However, his interests from an early age lay in natural history and this became a strong theme throughout his life.

Rev. John Gunn (Source www.bbc.co.uk/ yourpaintings)

The Norfolk coast seems to have encouraged an impressive amount of geologists and Gunn was certainly part of this. Taking his early geological lessons from Samuel Woodward (English geologist and antiquary: 1790 – 1838), he went on to be friends with Rev. James Layton and Anna Gurney (Forest bed collector, Cromer: 1795 – 1857) and to marry Harriet Turner, the daughter of Dawson Turner, a close friend of Layton's and an eminent banker/botanist. With such an interest in natural history it is not surprising that in 1869, after 40 years in the ministry, Gunn gave up his position, no longer able to conscientiously preach some of the doctrines of the Church of England. This dedication to the subject was also remarked upon in his obituary after his death in 1890 where he was described as "...one of the last links with geologists of the present day and those who laid the foundations of the science" (Geological Magazine 1890, 331).

Gunn's collection was presented to the Norfolk and Norwich Museum in 1868, whilst he was still alive. His offshore component comprises a mixture of Late Pleistocene elements, such as woolly mammoth, and those from the early-Middle Pleistocene such as southern mammoth and extinct forms of giant deer, perhaps reflecting its mixture between collection from the Great Yarmouth fleets, and those labelled simply as being from 'off Norfolk' (Section 3.2.3).

John Owles



Location of Owles' home and of his collection

Little is really known about John Owles other than he lived in Great Yarmouth with his wife Mary Whiley (married 23rd January 1831). He was elected a councillor in 1839 and retained this position at least until the 1850s (Denby-Palmer, Yarmouth notes; Gutenburg Project), but was a chemist/druggist by trade. He died in 1873, aged 65.

In addition to an extremely valuable collection of porcelain and pottery (Owles 1872), Owles collected a large number of fossils from the East Coast and Dogger grounds (Davies 1878, 97). These are dominated by 'post-glacial' (Late Pleistocene) species such as woolly mammoth, reindeer and bison (*ibid.*) and were purchased by the British Museum (Natural History) the year after his death (1874).

Acquired throughout the burgeoning years of the trawling industry in Great Yarmouth (Section 3.2.3), these fossils form a large part of this research's collection from the more northerly grounds on and around the Dogger Bank.

3.4.2 Their collections

The notes of collectors such as Layton, Gunn and Owles show that by the mid-19th Century collectors were well aware of the types of species they were finding, and of their significance (Layton 1827; Davies 1878). It has been noted by Reid (1913, 39-42), for example, that the majority of fossils found off Happisburgh belong to *Mammuthus meridionalis* (an Early Pleistocene *Mammuthus* [Lister and Bahn 1995]), whereas those from the Dogger Bank appear to represent younger species from after the Elsterian Glaciation, which already indicates an acknowledgement that certain deposits outcropping in areas of the seabed were temporally distinct from one another. This is something that has also been noted by various historic labels on trawled specimens, which refer to 'bonebeds' and 'graveyards' offshore (Figure 3.12); people were clearly aware of defined locations where this material was exposed.

The collections accumulated by collectors were usually sold off to museums or, in some cases, to auction houses. As a result, the specimens sometimes became globally dispersed (e.g. New York Times 1906). This was usually around the time of death, by the collectors themselves, or later by members of the family. For example, records show that Reverend James Layton sold his collection to the British Museum/Natural History Museum in 1858, and died the following year (pers. comm. Ian Layton), whereas John Owles died in 1873 (www.greatyarmouthhistory.com) with his collection being registered in 1874, and J.J. Colman died in 1898, the same year as his specimens were acquisitioned to the Norwich Castle Museum.

Figure 3.12 *Elephas sp*. molar with a label noting 'dredged from "Grave Yard"' (Colchester Museums Service)

The collections have been held by museums since then, but nearly always with little attention, trawled material being seen as without location and therefore without value. With their respective collectors appearing to have been primarily interested in either 'curiosities' or natural history, there is a collection bias which affects the associated information. In the latter case it is more likely that there will be documentation about the finds, at least in a general sense (e.g. Layton 1827; Williams 1878). However, in either case it is unlikely that there will be any exact account of provenance for the specimens as this level of information was simply not relevant to them, and labels are reduced to a very generalised location such as 'off Lowestoft' or even 'North Sea'. In a few cases this might be more specific, for example '40miles E of Lowestoft', or refer to specific locations such as 'Hasbro Oyster Bed'. Unfortunately, however, these are rare examples and so a broader perspective must be taken with the vast majority of the material.

Knowing when a specimen was dredged from the seabed also has implications for potential groupings and locations. The vast majority of the specimens, however, provide only the date of acquisition, which as discussed generally correlates with the death of the collector and the sale or donation of their collections. These dates therefore provide a kind of *terminus post quem* for the specimens' collection date, with only the occasional instance of being more precise (21% of the entire collection, 3% of the historic collection: this is an important distinction, as the recently-collected material has good provenance, whereas the locations of historic material rely on the trawling patterns).

3.4.3 Summary

Understanding the inspirations and locations of the antiquarians responsible for specimen curation helps to clarify the locations of their collections. Furthermore, the date of death often corresponds with the date of acquisition in the museums' registers, which helps to explain what could appear to be prolific collection years in the recovery record (see Figures 3.9, 3.11) but which actually represent the purchase or donation of huge collections. Investigating these kinds of issues can therefore help to elucidate patterning in the record, drawing out biases and important relationships.

3.5 Discussion

The preceding sections have discussed the various strands of evidence that have significant bearings on the recovery and location of Pleistocene fossil material: the trawling grounds, the development of the fishing industry, the collectors and their collections, and the myriad social implications of this. Pulling all of this information together allows an assessment of how far we can refine the locations of these fossils and why they are derived from the fleets that they appear to be derived from.

Significant changes have occurred throughout the 200 years since the inception of the trawling industry, with the introduction of steam being arguably the most influential (Butcher 1980; Robinson 1996; Engelhard 2008). Throughout this time, great social changes were also at play, with the industrial revolution giving rise to the modern capitalist economy. This in turn drove much of the development of the larger trawling businesses in the north-east, as well as Great Yarmouth (Section 3.2.1), and, at another level, the emergence of a more questioning and secular society pushing the boundaries of science. Furthermore, the increasing polarisation of amateur and professional roles throughout this time (McNabb 2012), in this case within the roles of natural historians and museums, meant that the numbers of specimens being both recovered and reported began to decline.

Figure 3.13 shows the combination of a timeline of the development of the trawling industry with the acquisition and collection of finds through the same period. Perhaps the broadest, yet most important, pattern is the changing frequencies of fossil recovery through time. As discussed, the majority of these dates act as a *terminus ante quem* for the specimens meaning that where peaks in numbers are seen, these could have been recovered at any point up to and including this date (with the exception of the BMAPA/Colchester peak, which is well constrained). The † symbol shown in Figure 3.13 shows the death of a major collector, which has had a dramatic effect on the numbers per decade. J. Owles, for example, whose collection numbers 207 specimens, died in 1873 and his collection was acquired in 1874. Interestingly, it was not only death that prompted donations of collections: J.J. Colman donated his collection of 34 specimens in 1877 but did not die until 1898. However, in 1878 he acquired a prolific library collection and began to invest heavily in its curation and expansion (Norfolk.gov.uk – special collections), which perhaps indicates that the sale or donation of his fossil collection was a tactical move and a precursor to this new literary passion.

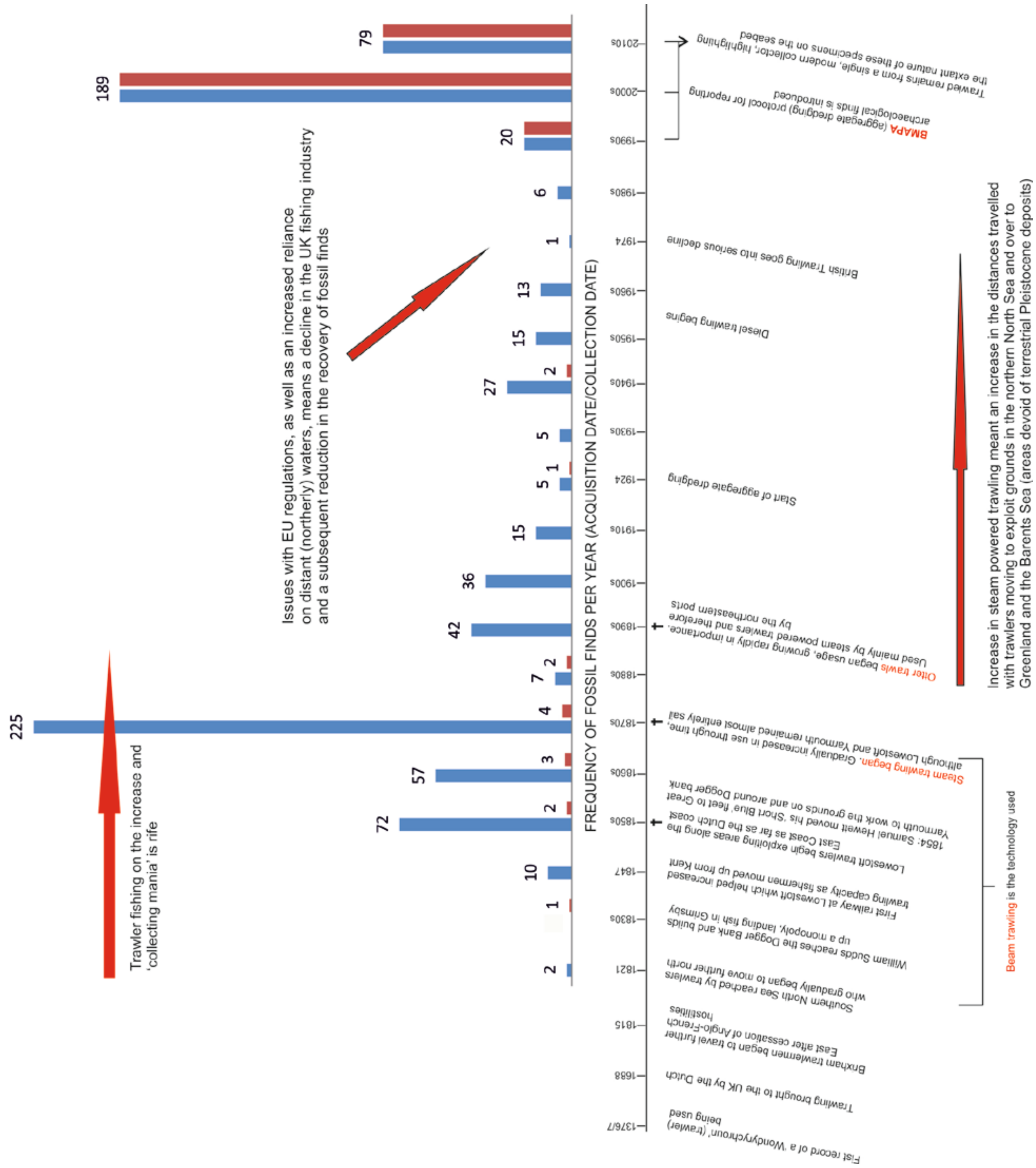


Figure 3.13 Timeline of the development of the trawling industry in the North Sea against the frequency of specimens recovered. The red columns show the frequency of fossils by collection year (where known), with the blue showing the same information by acquisition year.

The discrepancies between the actual collection and acquisition dates do present a potential bias. Where we can investigate the lives of the collectors we can account for this, but for the majority of the collectors this is not the case and some specimens that have been collected throughout the 19th Century may have been kept in families for generations and donated much later. Unfortunately, with the level of detail available for most the specimens this is impossible to account for, but given the smaller sample sizes attributable to the majority of collectors it should not present a major bias.

The increase in numbers throughout the 19th Century correlates with the increase in trawler fishing in the southern North Sea and is likely to be due to the combination of this and the collecting mania of the Victorian era. Increasing polarisation between professionals and amateurs during the early-mid 20th Century (McNabb 2012) may have played a part in the decline that we see throughout this later period, with fewer collectors interacting with museums and, potentially, fewer actual collectors. The mid-20th Century saw a drastic decline in the British trawling industry, especially in the depleted stocks of the southern North Sea, with trawlers moving further afield to more northerly grounds around Greenland and Iceland from the late 1890s. European Union laws and regulations from the 1970s also massively curtailed the amount of trawling that could take place and, in consequence, the numbers of fossils collected.

One of the most significant points highlighted by Figure 3.13 is the abundance of fossil material still extant today. If it were not for the collections of the modern trawler off Clacton and the BMAPA material from the 1980s onwards, the picture would imply that the seabed resource was seriously depleted, if not eradicated. However, the inclusion of these datasets presents an entirely different, far more positive, picture of the situation, with an abundance of fossil material. Recent work conducted by Dutch researchers in the same sea supports this assertion (van Kolfschoten and Laban 1995; Flemming 2004; Glimmerveen *et al.* 2006; Mol *et al.* 2006), and yet the reinvigoration of reporting and recording fossils from the UK sector is still embryonic and our relationships with the trawling and dredging industries relatively poor. Initiatives such as the BMAPA protocol and a recent project to engage with our dwindling trawling industry (Fishing Industry Protocol for Archaeological Discoveries) provide an opportunity to redress this problem and provide the details necessary to really get to grips with the extant resource on the seabed. But since these initiatives do not specifically focus on this kind of material, the level of detail available at present is frustratingly low. The spatial patterns identified through this research, as well as projects aimed at engagement with current fossil collectors, take this a stage further. By focusing on species identifications as well as locations, Chapter Four will present these results.

3.5.1 Geographical patterning

A clear pattern which emerges throughout this chapter is the lack of fossil material recovered from the north-eastern towns, despite the thriving trawling industries there during the 19th and 20th Centuries. Possible reasons for this discrepancy are:

- The method of fleeting's leading to difficult conditions and discontent among trawlermen, resulting in conditions not conducive to fossil collection.
- Company ownership associated with fleeting, meaning trawlermen were working for someone else and to someone else's timetable; again, the possibility that there was less flexibility with collection and sale of fossil material.
- The differences in the uses of otter versus beam trawling and the associated effects on the seabed that this produces, potentially resulting in a different degree of fossil recovery.
- An absence of antiquarian community in the north-east, perhaps owing to the relative lack of fossiliferous Quaternary deposits or gravel quarries to prompt or encourage such interests.

Several of these points, however, also apply to the Great Yarmouth fleets as well as those from the north-east: Great Yarmouth had fleeting as well as company ownership. The one difference was that Great Yarmouth remained a port dominated by sail, not steam, but the social issues outlined above would still apply. There must therefore be other factors causing these discrepancies.

The clear picture from the collectors is that they are almost entirely located in East Anglia, at least for a significant part of their lives. Is this due to the existence of renowned geology in this area, both invoking and encouraging interest in natural history? With the highly significant and well-preserved Quaternary coastal geology being on the door-step, there appears to have been a group of interested and socially-interrelated people that were involved with its study (Text Box 5). Furthermore, there existed a well-developed Natural History Society in and around Norwich, and Norfolk generally, possibly driven by the prolific quarrying industry exploiting the flint-rich deposits in this area, something that the towns in the northeast were lacking.

The presence of the East Anglian collectors could in fact be the impetus behind the curation-for-sale of fossils by the trawlermen, in a supply-and-demand sense. There are examples of the kinds of fates that the fossils befell otherwise, with Layton (1827, 200) recounting trawlermen finding: "…*various large bones…being found in great quantities…and as thrown away into deeper water*" as well as Reid (1890, 174): "…*many hundred specimens of the molar teeth…were destroyed by the fishermen, who amused themselves by breaking them*…". Once these trawlermen knew that there was interest in these specimens they began to bring them to shore for collectors and museums (Layton 1827, 200), but this was only after being encouraged to do so. If there was nobody requesting this material from areas such as Hull and Grimsby, perhaps this explains why nothing is recorded. Of course, there is always the possibility that the material has yet to be located within collections, but based on conversations with museum staff who have searched the archives, this seems increasingly unlikely.

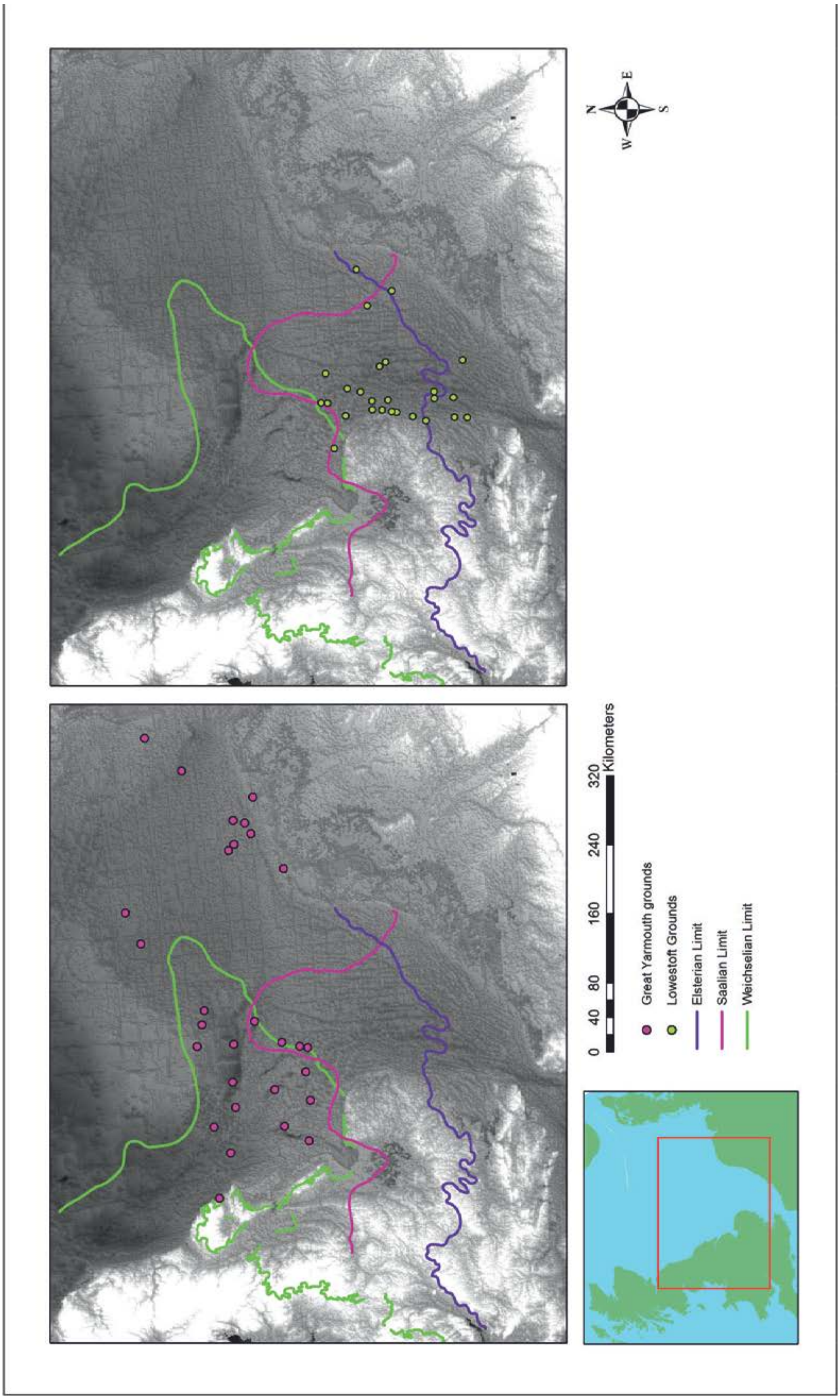


Figure 3.14 Distribution of Great Yarmouth and Lowestoft grounds relative to the three major glaciations (glacial limits after Graham *et al.* 2011; Lee *et al.* 2012. Elevation data source: Smith and Sandwell 1997)

The lack of inspiring Quaternary deposits, and resulting collectors, is probably very significant for the faunal collections, but the roots of this may also highlight why these fleets may not have been bringing back large amounts of material (if any). Cyclical glaciations which affected this part of North West Europe throughout the Middle – Late Pleistocene had a seriously detrimental effect on the preservation of Quaternary deposits. Whereas Britain, south of the Midlands, escaped direct glaciation after the extremes of the Elsterian, areas further north were subject to constant cycles of glaciation and its associated erosive effects (Figure 3.14). The southern North Sea would have been no exception, which may relate back to the negative pattern of finds from the fleets exploiting grounds to the north (Figure 3.4). This will be discussed further in Chapter Six, when the results of the species distributions will also be taken into account.

However the towns of Great Yarmouth and Lowestoft came to be the dominant areas of fossil recovery, using the territorial patterning of their trawling fleets will facilitate spatial analysis of where groups of fossils came from. If we apply what is known about the evolution of the taxonomic lineages of the species identified within these groups (Section 2.2.1), we can make an assessment of any temporal patterning.

The combination of these two elements will provide an insight into any spatio-temporal patterning with these assemblages, and this will have implications for the integrity of the seabed deposits. Are the specimens constantly being transported around the seabed in a totally derived, mixed state, or do they retain a Pleistocene context? In the latter case it would still be likely that some material will have been displaced, so presenting some background 'noise' in the results. This is demonstrated at a very local scale by the Area 240 results. These show 70% of species which belong to the *in situ* deposit and 30% material that is external (Russell and Tizzard 2011). This statistic will have important implications for the results seen in Chapter Four, as it suggests that you would expect to find a small proportion of species within any trawled assemblage that are not in fact representative of the deposit being disturbed.

3.6 Lithic component

Since lithics form the vast majority of the Palaeolithic archaeological record, it would be logical to start by looking for them from the submerged zone. This research initially set out to do so. As with the fauna, museums along the East Coast were contacted to ascertain what, if anything, they had in their collections.

Other than the aggregate-dredging site of Area 240, no lithic finds were recorded as coming in from the trawling industry or at all from the offshore zone. This was surprising, given the large collection of Mesolithic tools that have been recovered by an oyster dredger in the Solent (Momber *et al.* 2011), which indicates that recovering this material through trawling is not impossible. What some of the museums did have, however, were collections of material from the foreshore. All of this material was from the East Anglian and Essex coastlines.

From beach and foreshore collections along the East Anglian and north Essex coasts, one hundred and fifty two lithics were recorded, including the handaxes from beaches published in a short paper by Robins *et al.* (2008). These were collated from online resources such as the Portable Antiquities Scheme (PAS), Historic Environment Records (HERs) as well as identified museums' collections at Southend-on-Sea, Ipswich Museum, Norwich Castle Museum and records at Bury-St-Edmunds County Council. Their condition and location (from 6-figure grid references to simply a beach name, but often little else) was recorded and plotted in order to look for any significant patterning in the record.

Presented in Chapter Four, this work provides a baseline understanding of the lithics in this area and their locations along the foreshore. The question of whether they have been eroded from coastal deposits or washed in from the sea will be discussed, as well as the potential for looking at the movement of this material along the coast. The ongoing collation and analysis of these lithics is being conducted further by researchers at the Natural History and British Museums.

3.7 Conclusion

The development of this historical methodology allows the submerged resource to be redefined by imbuing it with a new level of context. With no previous research into the existing record from these landscapes, our understanding of what is available to work with was almost non-existent - with rare stumbled-upon sites floating among deposit models and abstract theories. Applying this methodology will allow a refinement of this dataset, demonstrating spatio-temporal patterning within broad areas of seabed and drawing out higher-resolution patterns from the coastal strip.

Returning to the questions posed in Chapter One, (*What is the nature of these specimens and the deposits they are contained within?; What do their distribution and patterning tell us about the offshore resource?)* this methodology has provided the framework within which we can place the specimens, directly addressing these questions and working towards a baseline understanding from which we can begin to delve deeper. It has also highlighted further issues worth investigating, such as the discrepancies between the records from the trawling industries of the north-eastern and East Anglian ports. Does this reflect offshore deposit patterning, does it suggest problems in actually finding datasets, or does it have its roots in more social factors?

Chapter Four will present this investigation beginning on a broad scale, examining the range of species represented from the entire areas, with more focused analyses of smaller, higher-resolution groups of data leading out of this. Using the same approach, but with additional focused datasets, Chapter Five will then present a case study demonstrating how this approach can be used to form an understanding of discrete areas of Palaeolithic deposits on the seabed.

Chapter 4: Spatial and temporal patterning of the submerged resource

Having set out the various means by which the prolific faunal resource from the southern North Sea can be investigated and refined, using inferences based on the development of the 19th Century trawling industry and contemporary antiquarians, this chapter examines its distribution and patterning. Given the nature of the information available - broad scale and historically derived - the statistical analysis has been kept to a level appropriate to the qualities of the data. Through using information about the territories of fleets from the fossil-yielding ports, groups of fossils will be assigned to broad regions of seabed. The taxonomic evolution of each of the species from these groups will then be ascertained in order to assess the spatio-temporal patterning within each area. Given the different types of trawling being practised - both broad territories as well as local, shoreward exploitation - the levels of resolution at which these spatio-temporal trends will be available will differ substantially, allowing a multi-scalar approach to this offshore picture.

It will be argued that there is significant spatial patterning emerging from these specimens, at all scales, and that this patterning indicates distinct areas of Palaeolithic potential on the seabed. The chance for this to be investigated further will be discussed and a case study doing so will be presented in the succeeding chapter. These results demonstrate for the first time the significance of the submerged faunal resource, as well as the potential that the existing record holds for furthering our knowledge about the occupation and use of these areas throughout the Palaeolithic.

4.1 The fauna

A database of 1,119 faunal specimens has been created through the collation of material in the museums' collections and online databases shown in Figure 3.2 (see Appendix of the raw data for this in the attached CD). Figure 4.1 details the species identified within this collection, showing the Latin name and common counterpart as well as the temporal range of each. Given the distinctiveness of species during the pre-Elsterian (Early and early Middle Pleistocene) compared with those from the post-Elsterian (late Middle to Late Pleistocene), at least in part owing to the faunal turnover that occurred during the Elsterian glaciation, these are the broad temporal ranges that have been adopted.

Latin name	**General Name**	**Temporal range (UK)**
Balcena biscayensis	Whale	Pleistocene
Bison priscus	Bison	Post-Elsterian
Bison sp.	Bison	Pleistocene
Bos primigenius	Aurochs	Post-Elsterian
Bos sp.	Aurochs	Indeterminate
Canis lupis	Grey wolf	Pleistocene
Castor fiber	Beaver	Pleistocene
Cervus elaphus	Red Deer	Pre-Elsterian
Cervalces latifrons	Deer	Pre-Elsterian
Cervus polignacus robert	Deer	Pre-Elsterian
Cervus sedgwicki falconer	Deer	Pre-Elsterian
Cervus sp.	Indet. Deer	Indeterminate
Cetacean	Whale	Indeterminate
Coelodonta antiquitatis	Woolly Rhinoceros	Post-Elsterian
Delphinapterus leucas	Beluga whale	Post-Elsterian
Elephas sp.	Mammoth/Elephant	Indeterminate
Equus caballus	Horse	Pleistocene
Equus sp.	Indet. Horse	Indeterminate
Euctenoceros sedgwicki (Falconer)	Deer	Pre-Elsterian
Crocuta sp.	Hyena	Indeterminate
Hippopotamus sp.	Hippopotamus	Pleistocene
Mammuthus meridionalis	Southern Mammoth	Pre-Elsterian

Mammuthus primigenius	Woolly Mammoth	Post-Elsterian
Mammuthus trogontherii	Steppe Mammoth	Pre-Elsterian
Praemegaceros dawkinski	Giant Deer	Pre-Elsterian
Megaloceros giganteus	Giant Deer	Post-Elsterian
Megaloceros savini	Giant Deer	Pre-Elsterian
Megaloceros sp.	Indet. Giant Deer	Indeterminate
Praemegaceros verticornis	Giant Deer	Pre-Elsterian
Odobenus rosmarus	Walrus	Post-Elsterian
Ovibos moschatus Zimmermann	Musk Ox	Post-Elsterian
Palaeoloxodon antiquus	Straight tusked elephant	Pleistocene
Rangifer tarandus	Reindeer	Post-Elsterian
Stephanorhinus etruscus	Rhinoceros	Pre-Elsterian
Stephanorhinus hemitoechus	Narrow nosed rhino	Post-Elsterian
Rhinoceros sp.	Indet. Rhinoceros	Indeterminate
Ruminant	Ruminant	Indeterminate
Sus sp.	Indet. Pig	Indeterminate
Trichechus huxleyi	Walus	Pre-Elsterian
Trichechus sp.	Walrus	Indeterminate
Turtle	Turtle	Indeterminate

Table 4.1 The species discussed in the text. Pre-Elsterian are not found after the Elsterian glaciation (in Britain), post-Elsterian species are only found after the Elsterian glaciation (in Britain), Pleistocene species are found both before and after the Elsterian glaciation, and Indeterminate specimens refer to material which is not able to be assigned to a species level and therefore does not have chronological information. Note that these are broad terms and that occurrence of species within these periods will fluctuate (see Figure 2.5)

The faunal specimens are represented by 42 genera, with 28 identified species. Of the collection, 78% (n=873) have been identified to genera with the remaining 22% (n=246) either identified to family level e.g. Bovid (16%, n=179) or unidentifiable (6%, n=67).

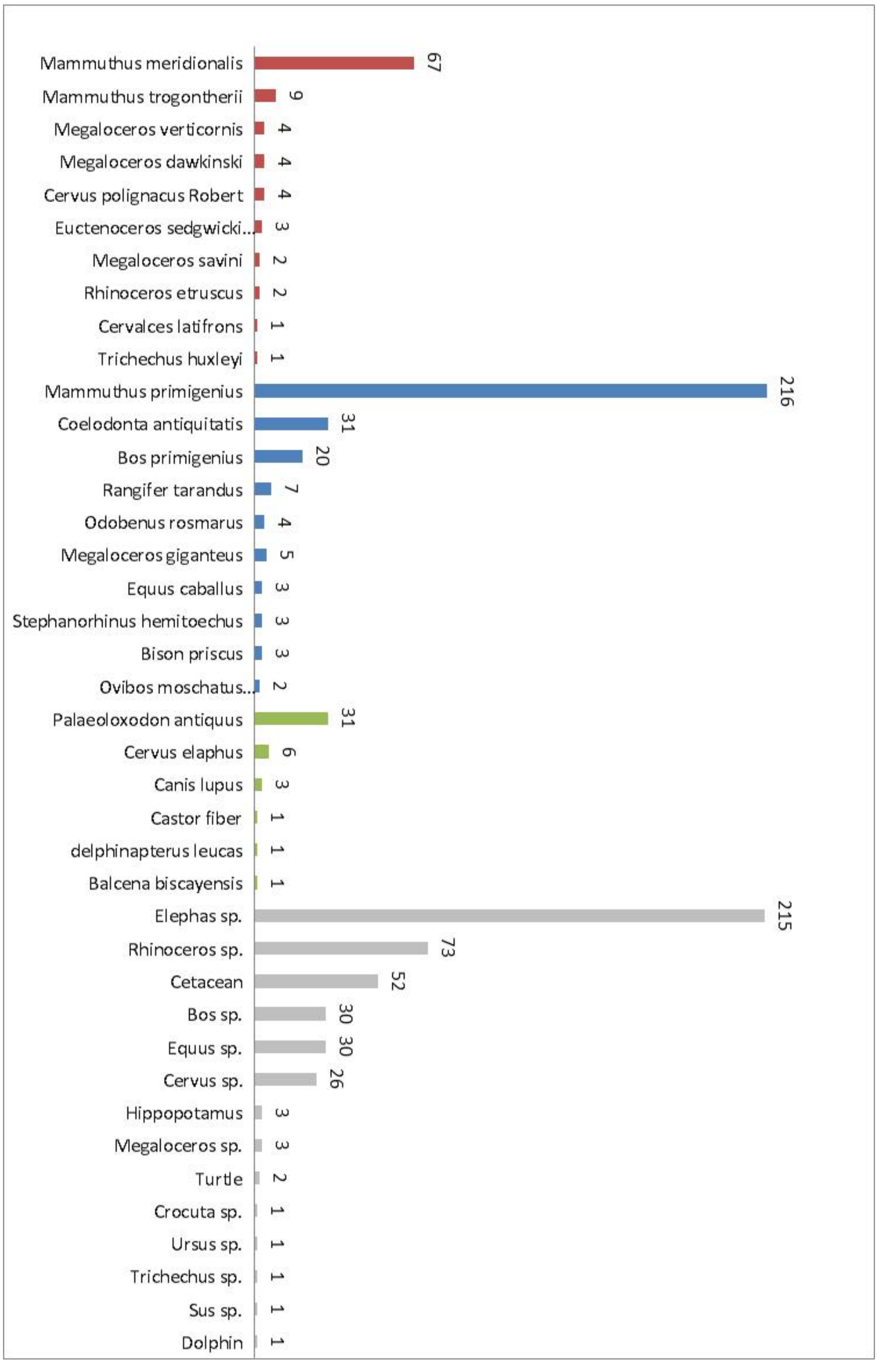


Figure 4.1 Proportions of all specimens recovered to family level or higher. Red = pre-Elsterian; Blue = post-Elsterian; Green = Species which span the Elsterian; Grey = Species only identified to genus.

Figure 4.1 shows the proportions of specimens that have been identified at least as far as genus level, with pre-Elsterian species in red (i.e. early Middle Pleistocene), post-Elsterian in blue (i.e. late Middle – Late Pleistocene) and species that are found throughout these periods in green. Those specimens that are only identified as far as genus are shown in grey. These are the colour distinctions that will be used throughout this thesis to denote these broad temporal patterns. The Elsterian has been taken as a marker point because of the significant effect that it had on species turnover in Britain as well as on the palaeogeography of the southern North Sea (and therefore available terrestrial landmass. See Chapter Two, Section 2.1. [Gibbard 1995; Gupta *et al.* 2007; Toucanne *et al.* 2009]). This will help to define broad spatio-temporal patterns, with the potential in some cases for more in-depth analysis of species' temporal distribution.

Within the assemblage there are clearly dominant species. Unsurprisingly, owing to their increased robusticity, these are all large-boned mammals such as mammoths, elephants and whales. Large bovids such as aurochs (*Bos*) and rhinoceros are also well represented. These large bones would not only stand a better chance of survival but would be more easily picked up by, and far more conspicuous, in trawling nets.

At 48% (n=538), mammoth and elephant species represent almost half the entire collection, with those identified to species representing 29% (n=323). The unidentified *Elephas sp.* represents 19% (n=215). Similarly, *Rhinoceros sp.* (7%, n=73) and *Bos sp.* (3%, n=30) could represent species from both pre and post Elsterian, which limits their use as chronological markers. Further work on these specimens may help to clarify them to species, but this would require the use of reference collections and a new in-depth analysis. It is not therefore within the remit of this PhD but forms part of suggested future work. So, taking these indeterminate groups out leaves us with a clearer picture of what there is to work with ([n=434] Figure 4.2).

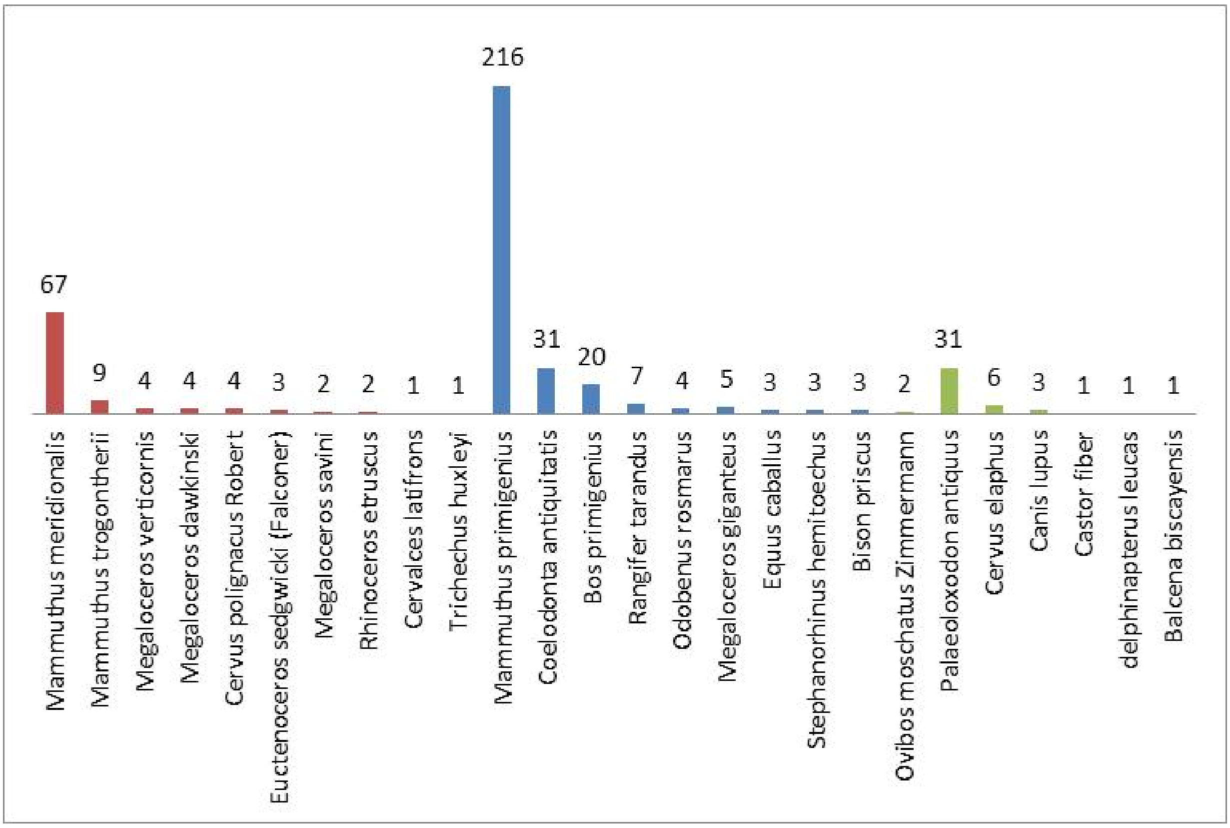
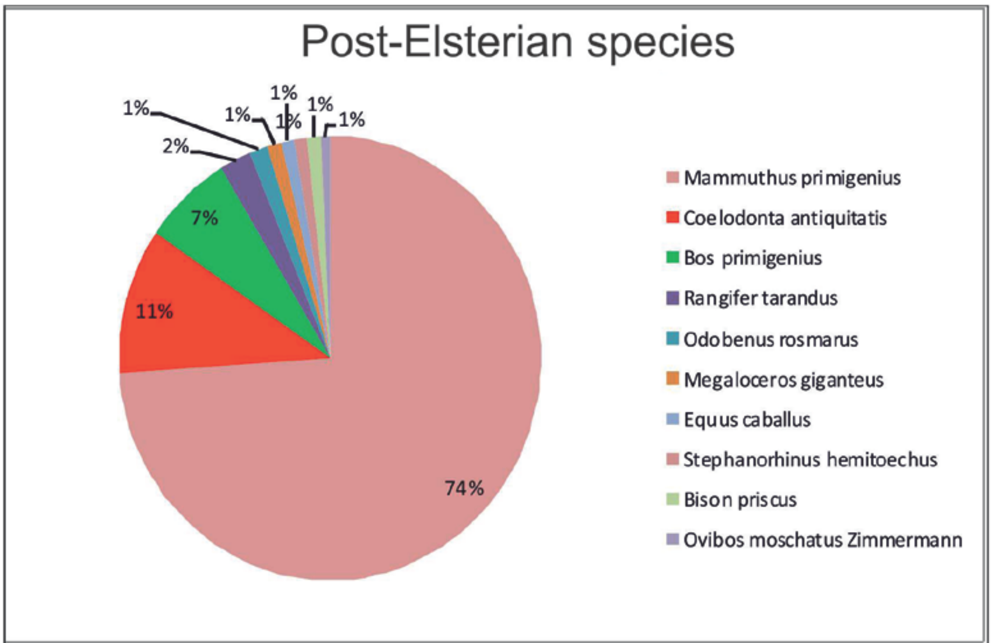


Figure 4.2 Proportions of specimens recovered that are identified to species level

The species-level collection (n=434) is dominated by species from the post-Elsterian, late Middle and Late Pleistocene (67%), with the similar proportions of mammoth or elephant specimens from each broad period indicating that this pattern is not biased by the large numbers of woolly mammoth specimens.

The post-Elsterian species offer further scope for narrowing down the faunal groupings, as several species appear at different points and commonly form part of a common assemblage type (Mammal Assemblage Zone [MAZ]). There are 10 species identified as post-Elsterian, 74% of which are *Mammuthus primigenius* (Woolly Mammoth, n=216), 11% are *Coelodonta antiquitis* (woolly rhino n=31), 7% of which are *Bos primigenius* (Aurochs, n=20), 2% of which are *Rangifer tarandus* (Reindeer, n=7), 1% are *Odobenus rosmarus* (walrus, n=4), *Equus* (horse, n=3), *Stephanorhinus hemitoechus* (narrow nosed rhino, n=3), *Bison priscus* (n=3) and *Megaloceros giganteus* (giant deer, n=3) and <1% of which are *Ovibos moschatus* Musk Ox (n=1) (Figure 4.3). It is clear that all the species (aside from *Bos primigenius* and *Stephanorhinus hemitoechus*) from the offshore dataset could be associated with the 'mammoth steppe' assemblage type (Guthrie 1982), which potentially links them to the periglacial environments that prevailed in the southern North Sea throughout the Late Pleistocene period. However, several of these species (*Coelodonta antiquitatis, Mammuthus primigenius, Equus* and *Bison priscus*) have also been found within coombe rock deposits in the Ebbsfleet Valley dated (by association with overlying interglacial deposits of MIS 9 fluvial 'Mucking Terrace' [Bridgland 1994]) to MIS 8. These species therefore appear to have been present within this earlier, Middle Pleistocene glacial period, making their association with the Late Pleistocene less conclusive but placing them within the period of the mammoth steppe environments (Guthrie 1982).



Pin Hole Fauna
Homo sp. - Human
Lepus timidus – Mountain hare
Spermophilous major – Red-cheeked suslik
Canis lupus - Wolf
Vulpes vulpes – Red fox
Ursus arctos – Arctic bear
Mustela ermine - Stoat
Mustela putorius - Polecat
Crocuta crocuta – Spotted hyaena
Panthera leo - Lion
Mammuthus primigenius – Woolly mammoth
Equus ferus – Wild horse
Coelodonta antiquitatis – Woolly rhino
Megaloceros giganteus – Giant deer
Rangifer tarandus - Reindeer
Bison priscus - Bison
From other MIS 3 assemblages
Cervus elaphus (Linnaeus 1758) – Red deer
Ovibos moschatus (Mol et al. 2006) – Musk ox
Equus caballus (Mol et al. 2006) - Horse
Odobenus rosmarus (Mol et al. 2006) - Walrus

Figure 4.3 Pie chart displaying the post-Elsterian, Middle – Late Pleistocene species represented in the dataset, with the table showing the 'Mammoth fauna' species found during MIS 3 (after Linnaeus 1758; Mol *et al.* 2006; Currant and Jacobi 2011)

The dominance of post-Elsterian species is unsurprising for several reasons. Having been in existence the most recently, they would not only have had less time to be eroded or destroyed but are also more likely to be found in outcropping or more surficial deposits. Furthermore, the change in intensity of the glaciations that occurred, starting with the Elsterian glaciation (the first major expression of a dominant eccentricity forcing in Britain [Rose 2010]), led to far lower sea levels than had previously been witnessed during pre-Elsterian stages. These cold-stage periods of lowered sea level would therefore have provided dry land further north than the preceding low stands of the early Middle Pleistocene (Figure 2.2), so that species from this period would be more geographically dispersed.

Despite the dominance of younger species, the relatively high number of pre-Elsterian species (22%, n=97) also demonstrates the survival of these specimens over significant periods of time and the potential for archaeologically-relevant deposits of different ages surviving on the seabed. However, the burial of deposits from these earlier periods means that their potential for outcropping on the seabed is reduced, as seen through modern geological maps, which makes these specimens fewer and farther between but potentially narrows down their locations.

In terms of narrowing the species within this group down further, the pre-Elsterian species (other than *Stephanorhinus etruscus*, which is an Early Pleistocene species) are all found within the early Middle Pleistocene, although *Mammuthus meridionalis* is at the latter stages of its evolution and is also representative of the Early Pleistocene. It is not possible to distinguish between stages of the early Middle Pleistocene with this amount of evidence, but this is being investigated with respect to some recently-collected beach material (Parfitt pers. comm.).

4.1.1 Element types

A brief discussion of the types of bone elements recovered is necessary in order to assess biases both in terms of recovery (significant enough to get caught in nets) and curation (interesting to collectors). Suggesting what would and would not be interesting to collectors is always going to involve assumptions about preference but, given that many collectors would have been looking for the spectacular (as they are today, hence these fossils selling globally), large and identifiable bones are likely to dominate. Clearly, large bones are also likely to dominate as they are easier to catch in nets and to notice.

Figure 4.4 shows two graphs, which demonstrate the frequency of the elements recovered for both the entire collection as well as the collection with *Mammuthus* specimens removed. From Figures 4.1 and 4.2 it is clear that *Mammuthus sp.* form a large proportion of the collection. The reasons for removing *Mammuthus* were therefore to assess the distribution of species (and hence elements) of a smaller size.

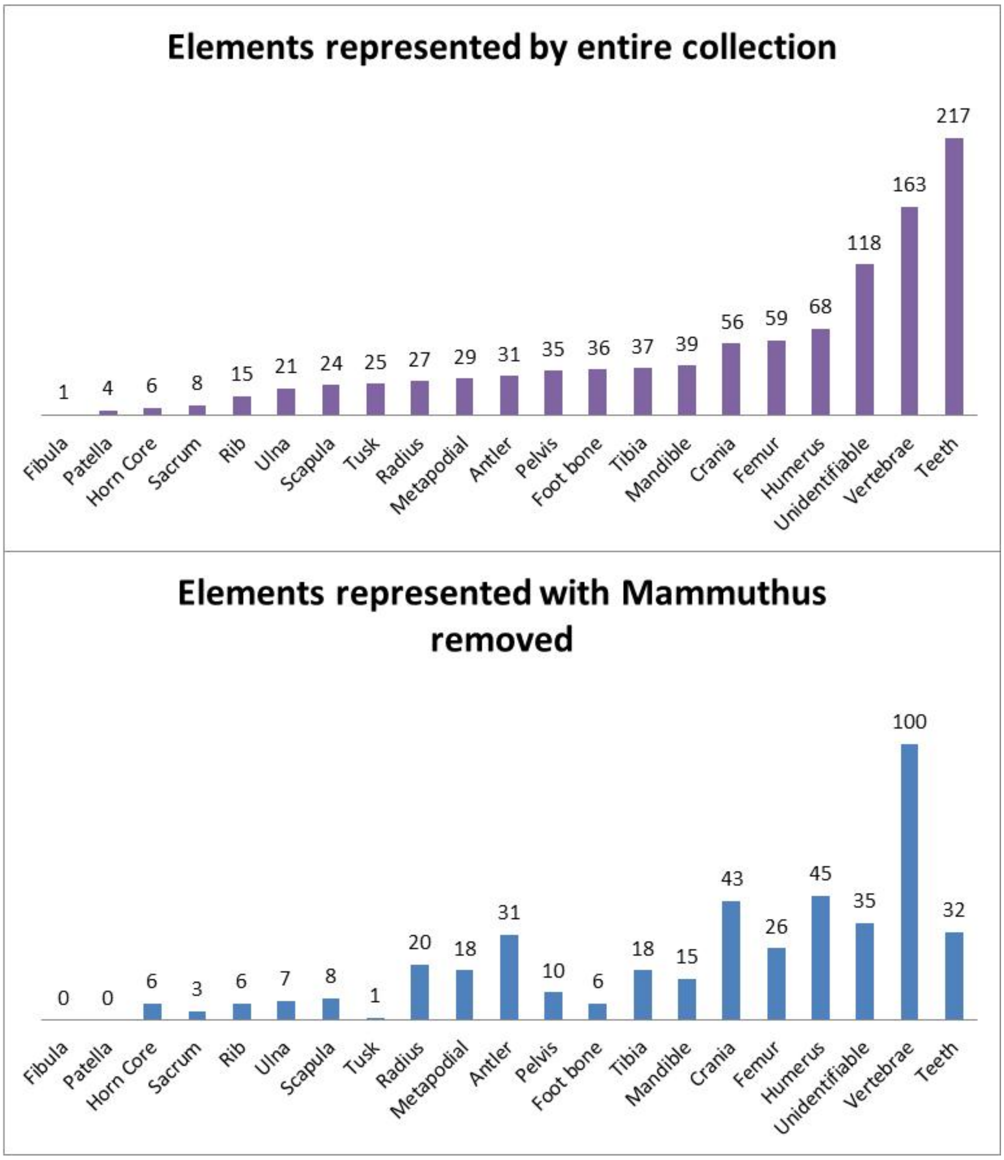


Figure 4.4 Showing the frequency of elements recovered. Top graph shows these elements for the entire collection, the bottom graph shows them with *Mammuthus sp*. removed.

Figure 4.4 demonstrates the prevalence of large and immediately-identifiable bones such as teeth and vertebrae. The smaller long bones, such as the ulna and metapodials, are more poorly represented than the larger long bones such as the femur and humerus. Crania are well represented in both cases, probably owing more to its thick, robust bone than to recognition, as many crania fragments are far from easily identifiable.

The main point that the removal of *Mammuthus* material demonstrates is the better representation of smaller elements such as foot bones for these much larger species. The astragalus of a *Mammuthus sp.* is relatively large compared with a species such as *Equus sp.* (Figure 4.5) and would be far less likely to slip through the net.

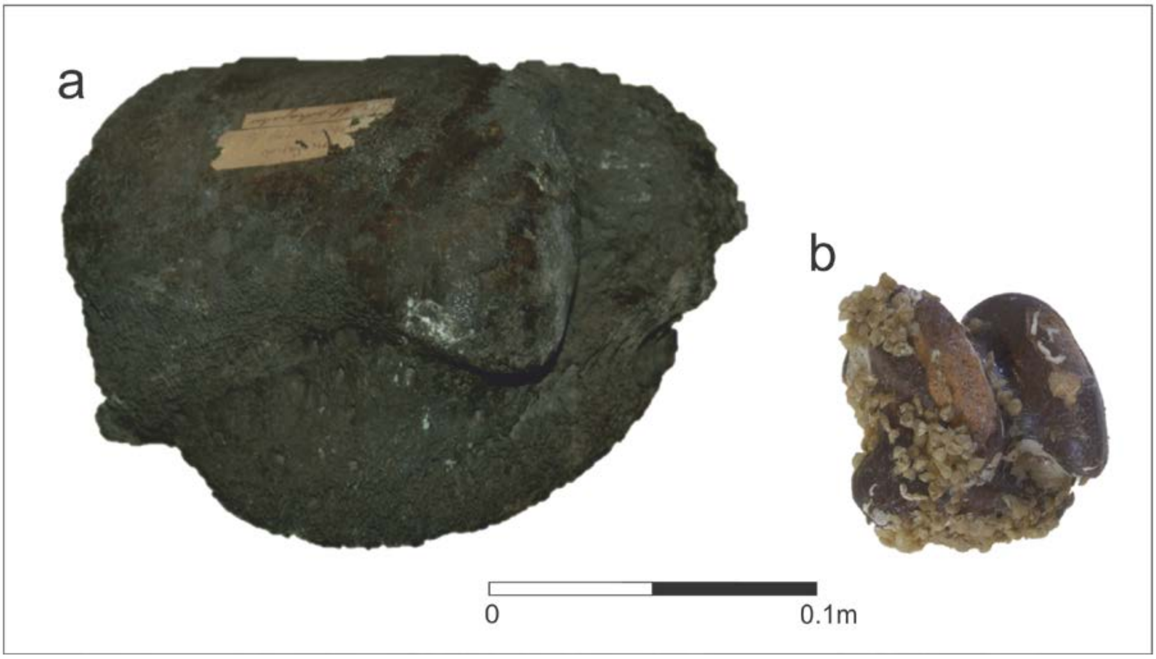


Figure 4.5 Two astragali showing the difference in size. a. *Mammuthus meridionalis* (southern mammoth); b. *Equus sp.* (horse)

Importantly, Figure 4.4 also shows that the collection has representation from almost all elements of the skeleton and that even smaller elements of smaller species are being preserved and recovered. This is supported by Figure 4.6, which (although based only on the specimens from the NHM [n=339]) shows a wide range of sizes represented. It is interesting to note that the specimens recovered within this collection are no smaller than approximately 0.1m in either width or length; this corresponds with the net mesh size of 0.08m for dover sole, one of the dominant fish species exploited (Section 3.2.1).

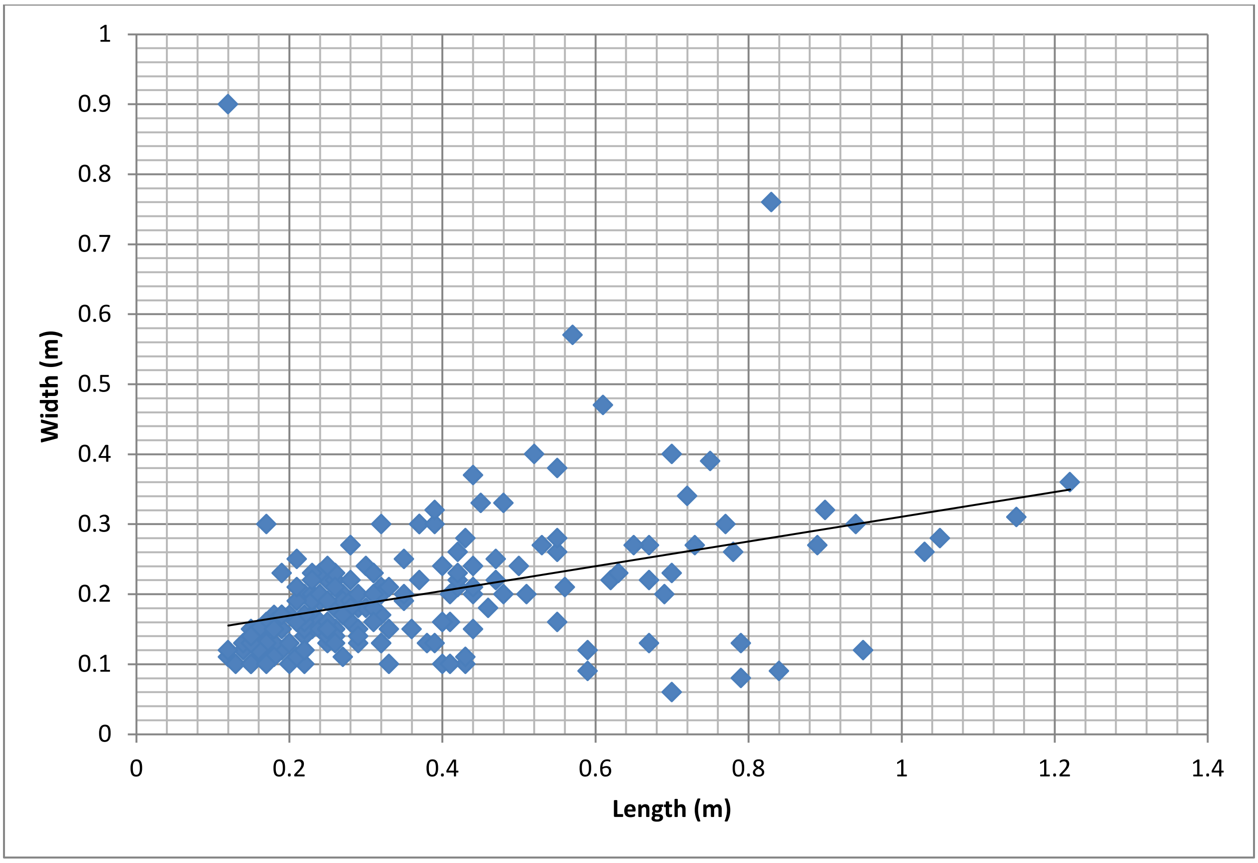


Figure 4.6 Showing the relationship between maximum length and maximum width of the specimens from the NHM, London (n=339)

4.1.2 Condition of the specimens

The condition of the specimens collated range from well preserved to almost entirely rounded, as well as displaying different degrees and types of marine growth. However, because of time limitations whilst recording the material this information is not available for the entire collection. A subset of the collection (the Natural History Museums' collection) will therefore be examined and presented as a case study here in order to give an idea of its potential for future work. This was a subjective study, without scientific or specific quantification and, at this stage, is useful to present the range of conditions and their proportions within the collection, and subsequently for making broad assertions about possible movement and exposure.

In terms of abrasion there are different distinctions to be made between bones with surface weathering and rounded edges and those which are generally unabraded but have weathering to their extremities. In terms of the formation of these patterns it is difficult to determine the cause: were they in this condition before submergence through surface, chemical or fluvial weathering, or is this a result of movement in the marine zone? These are questions that are more able to be addressed when the nature of the deposit the specimens are derived from is known and, as such, will be far more influential in any future work which deals with pinpointing specific areas of seabed.

Out of 205 specimens from the NHM which have recorded information (a large collection (n=121) are missing): 58% (n=119) have marine growth, 27% (n=56) are broken, 11% (n=22) show abrasion, and 21% (n=43) have both abrasion and breakage. Breakage is generally of the more delicate extremities and the numbers shown refer to specimens showing significant breaks of the bone ends or edges, with visual inspection of the bones indicating that the majority do, in fact, show signs of smaller breaks to the thinner, less robust areas. Figure 4.7 gives examples of the range of conditions present.

Figure 4.7 Bones showing a range of conditions. a. a *cervus* antler base, with very rounded edges and breakage; b. a mandible of *Trichechus huxleyi* showing surface abrasion and some marine growth; c. atlas of *rhinoceros sp.* showing marine growth as well as extensive breakage; d. *Coelodonta antiquitatis* mandible showing some breakage of extremities but a well preserved bone surface; e. pelvis of *Cervus sp.* showing breakage at the extremities but sharp edges and a relatively well preserved bone surface; f. an atlas of *Canis lupus* showing a well preserved bone surface and no breakage.

Abrasion is also often present at the extremities of the specimens, but can also refer to weathering of the bone surface. This type of surface weathering is often seen with terrestrial archaeological collections and may relate to chemical weathering that may be pre-submergence.

In terms of the types of bones affected, the larger bones, such as the humerus and pelvis, appear to have more breakage than the smaller bones, such as foot bones (Figure 4.8). This is probably because of their larger surface area presenting more opportunities for being struck or crushed. Many of the shafts of the larger bones also have hollow cavities and a greater bone thickness to overall size ratio; smaller bones, such as foot bones or ribs, are either solid or have a lower bone thickness to size ratio, potentially making them relatively more robust. It is also interesting to note that the bones which display the most recorded breakage are those with vulnerable extremities, such as the spinal processes of vertebrae.

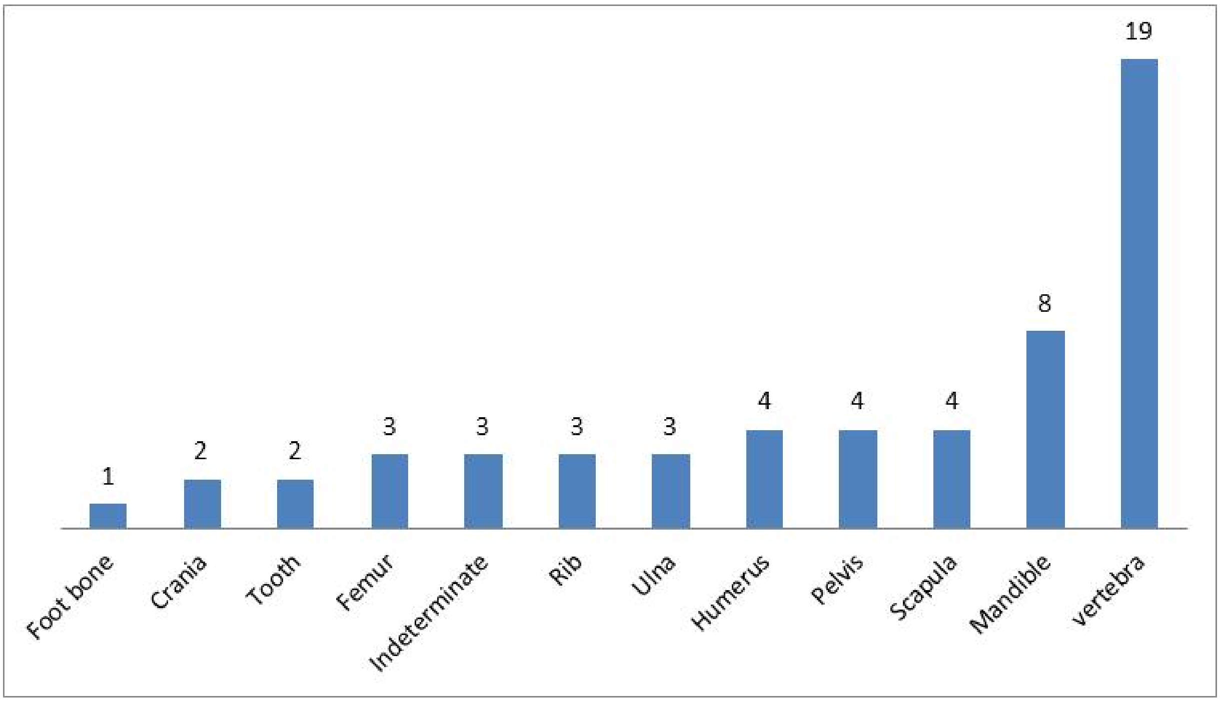


Figure 4.8 Frequencies of bones displaying breakage

Marine growth is present on most specimens to some degree, with those included in the 56% above demonstrating obvious growth (see Figure 4.7). Other associated indications are where the marine growth is restricted to only one side of a specimen, or to only one portion, possibly indicating only partial exposure. The species of colonising marine creature may also be able to demonstrate water depths and seabed type, although this would require a far closer examination of the collections. A potential issue with this (especially in terms of historic collections) is discerning the degree to which the specimens have been cleaned-up and therefore had this evidence removed. Modern sources have indicated that the removal of marine growth is common both for aesthetic reasons as well as because of the resulting smell if they are left (Brand pers. comm.). This may therefore be best addressed by future studies utilising recently collected material.

This is useful for highlighting the possible degree of movement of the specimens on the seabed prior to recovery as well as their exposure. However, there are factors that will need to be taken into account before this approach is taken further:

- Is there a way to determine whether the breakage is pre- or post-depositional?
- Is there a significant difference in the condition of recent seabed breaks compared with those received whilst being trawled from the seabed; can the two be distinguished?
- Is bone surface weathering something that occurs in marine conditions, or is this type of weathering a terrestrial phenomenon?

Given that the majority of archaeological specimens are not pristine, it would be interesting to assess the amount of weathering and erosion that bone specimens are subject to purely from marine erosion – can the patterns indicate whether erosion has come from mobile sediments as opposed to actual movement as part of bedload, for example - with these patterns helping to understand the histories of the specimens and therefore helping to further characterise the nature of their yielding deposits.

4.2 **Locations**

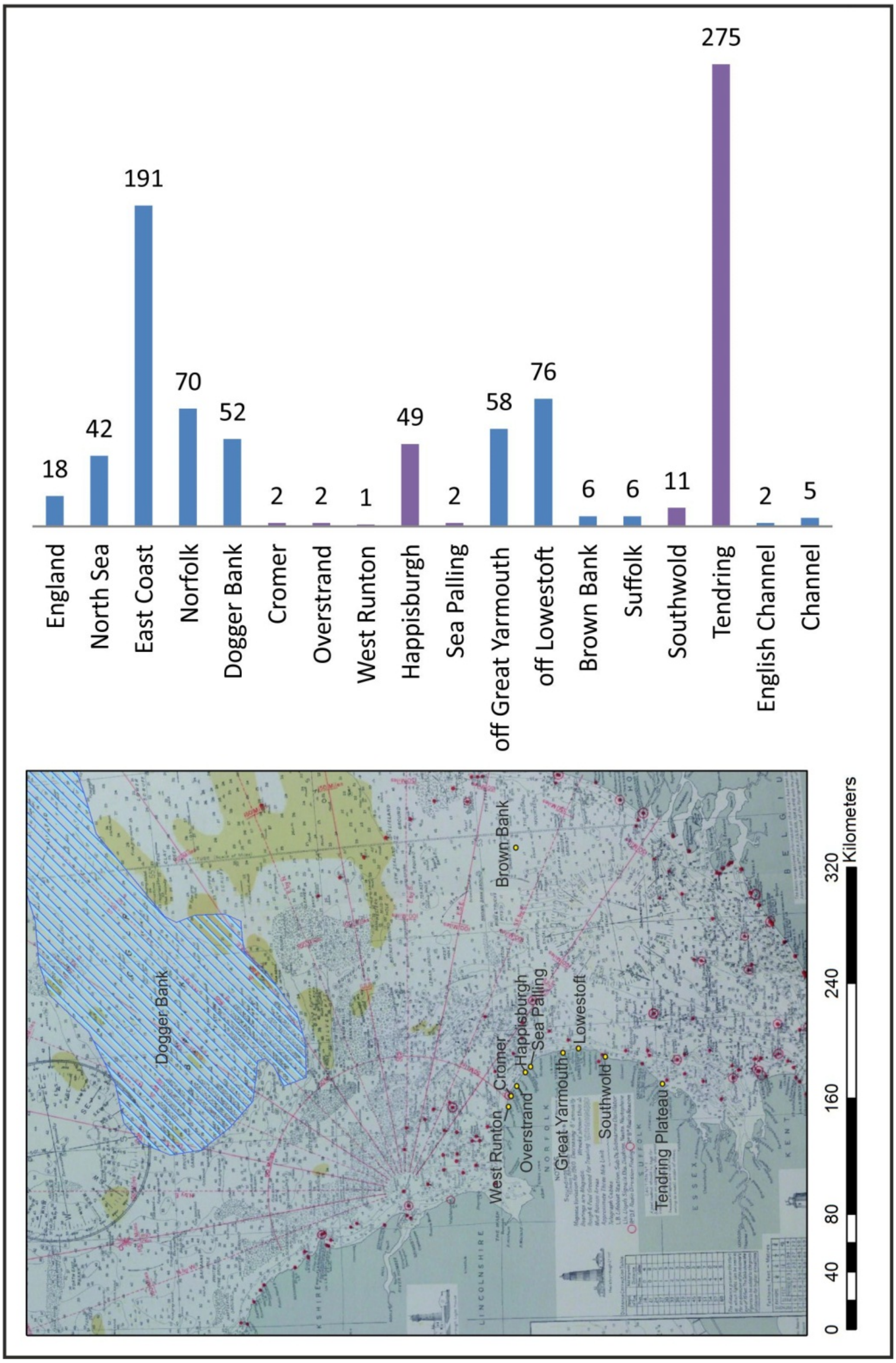


Figure 4.9 Range of locations given for the recovery of specimens, with the purple representing local, small-scale trawling and the blue representing the broader areas exploited by more formalised fleets.

The various locations that the specimens derived from are shown in Figure 4.9. Whilst some of these are a little too broad to be of any specific value, such as 'North Sea' (n=42) and 'England' (n=18), others have more potential, albeit at varying levels. Working from the information derived from the development of the trawling industry, and the territorial nature of the exploitation of the seabed, it is clear that the trawlers working out of Great Yarmouth were exploiting grounds to the north of the Leman and Ower Banks on and around the Dogger Bank, but south of 55°N (Butcher 21980; Robinson 1996), whereas those off Lowestoft were moving from the Galloper in the south up to the Leman and Ower and across to near the Dutch coast (*ibid.* Section 3.2.3). In this case, it is possible to group the Great Yarmouth specimens with those from the Dogger Bank, and the specimens off Lowestoft with those off Norfolk and Suffolk. The information gleaned about the collectors can also help to refine some patterning, for example we know that Owles collected from the fleets at Great Yarmouth so his 'East Coast' specimens are synonymous with the grounds that these trawlers were exploiting. There are also smaller-scale patterns that can be derived where the trawling took place closer to the shore, off the beaches.

4.2.1 **Small-Scale locations**

The locations shown in purple bars on Figure 4.9 are all relatively localised and are also located on the map. These locations, such as Happisburgh or Southwold, are likely to represent smaller-scale, off-the-beach exploitation as they had no formal harbours from which to work (Smylie 1999; Butcher pers. comm.). It is always, however, possible that these smaller grounds were opportunistically exploited en-route to more substantial grounds (Layton 1827; Reid 1890, 174).

There are seven of these smaller-scale locations in this dataset, exploiting the seabed within sight of the shore: located off the Tendring Peninsula, Happisburgh, Cromer, Overstrand, West Runton, Sea Palling and Southwold. Figure 4.10 shows the distribution of species represented from these areas, showing the change in relative proportions along the coastline.

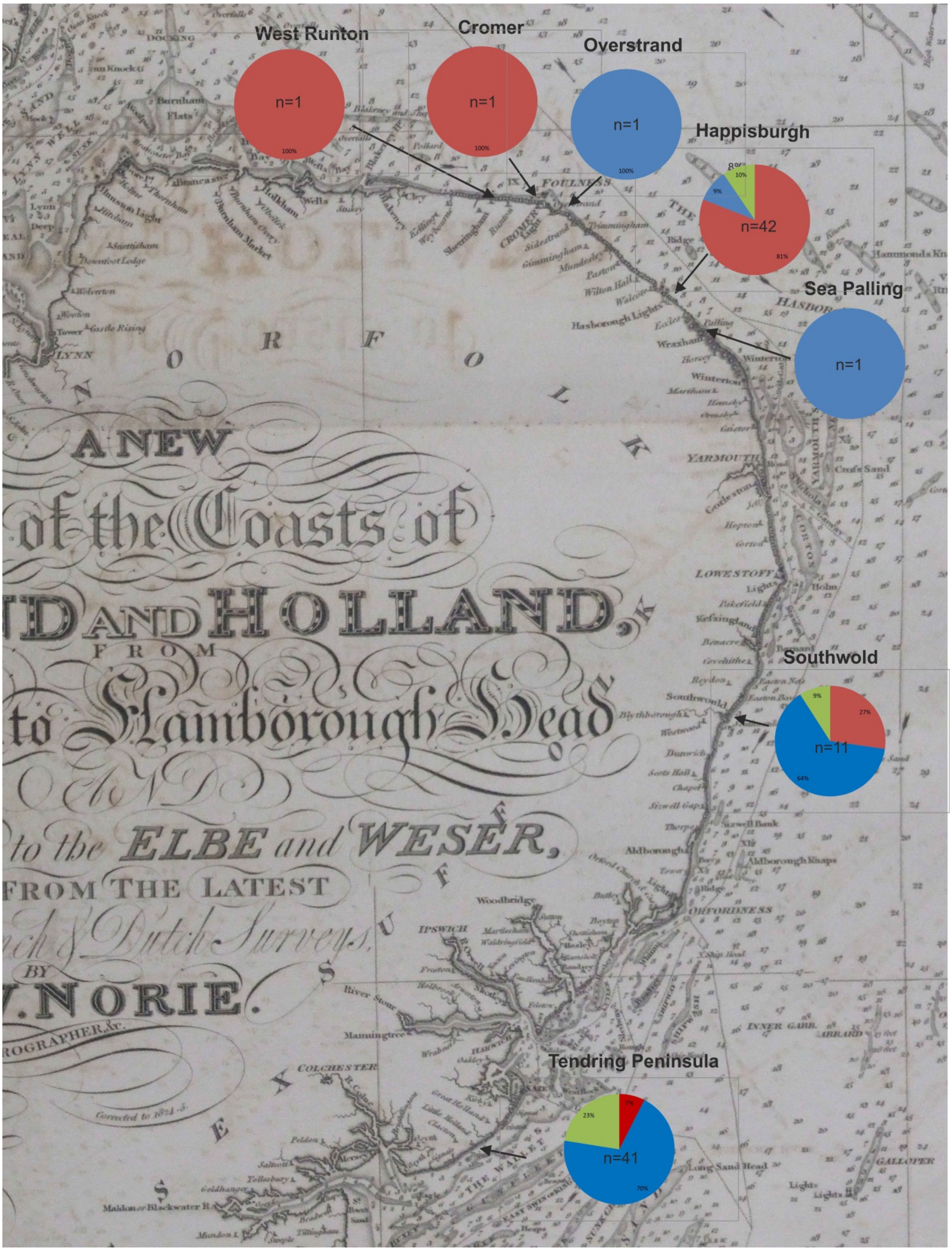


Figure 4.10 Proportions of species from small-scale locations along the coastline: red: pre-Elsterian; blue: post-Elsterian; green: spanning species.

North of (and including) Happisburgh, the majority of the species are pre-Elsterian (n=34), with these being dominated by *Mammuthus meridionalis* (Southern Mammoth [n=31]), which has its last appearance in this part of the world between MIS 19 and MIS 15 (0.8 and 0.6Ma [Lister and Stuart 2010]). Of the species that span the early Middle – Late Pleistocene, *Palaeoloxodon antiquus* (straight-tusked elephant) is the only one identified to species level and represented by more than one element in this assemblage (n=4, Figure 4.11). *Palaeloxodon antiquus* is an interglacial species and inhabited similar wooded environments to *Mammuthus meridionalis,* feeding off trees and shrubs and having a direct impact on their surrounding environments (Lister and Bahn 1995). However, the likelihood of these two species overlapping temporally is small, given that the first appearance of *Palaeoloxodon antiquus* in Britain is thought to be towards the later end of the early Middle Pleistocene (Preece and Parfitt 2012) and therefore more likely to coincide (temporally, at least) with the steppe mammoth, *Mammuthus trogontherii* (descended from, but overlapping with, *Mammuthus meridionalis*).

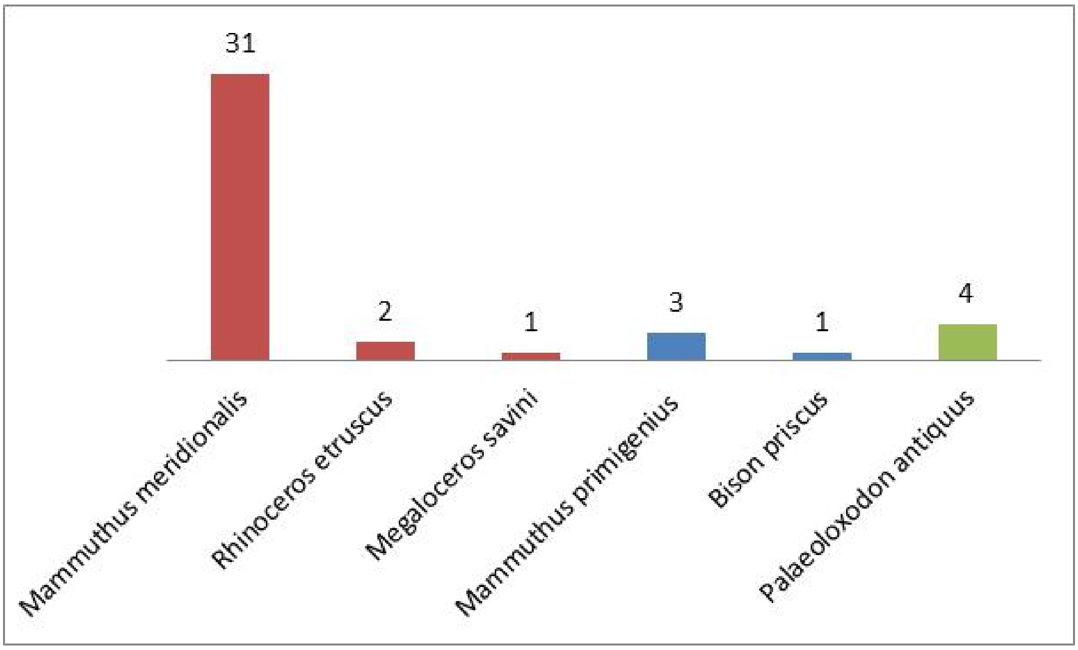


Figure 4.11 Species represented north of and including Happisburgh

South of Happisburgh the situation is reversed, with these areas dominated by post-Elsterian species (Figure 4.12). Sea Palling is a notable case, with only one specimen identifiable as being from this period (and a further one unidentifiable) and yet in such close proximity to Happisburgh, which is so heavily dominated by pre-Elsterian species. Such small sample sizes, from here as well as several of the north Norfolk locations, are potentially unreliable and so it is best to view them as part of a wider pattern as shown by Happisburgh, Southwold and Tendring. What is interesting about Sea Palling, and illustrates this point, is the existence of a large collection of faunal remains from the beach at this location that are heavily dominated by a pre-Elsterian assemblage and an Early Pleistocene assemblage (Parfitt pers. comm.). Although not recovered from the offshore zone, the matrix associated with these specimens is extremely similar to that recorded by Reid (1890, 173) as coming from the offshore deposits just off Happisburgh and Eccles (right next to Sea Palling) and form part of an 'Eccles' preservation type. Taking these specimens into account implies that this area, as seems logical, would be a very significant part of the pre-Elsterian group (Section 4.2.1.1).

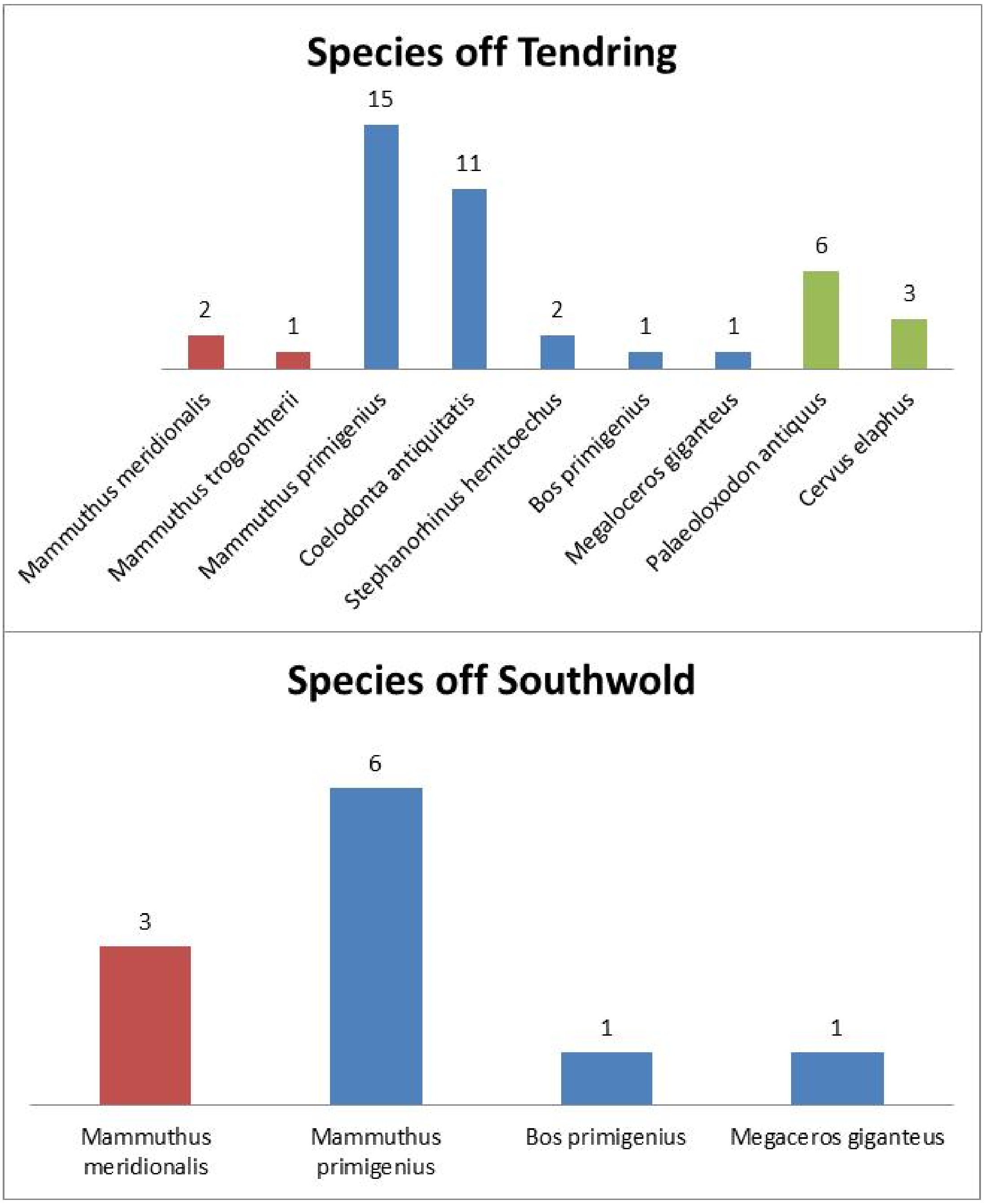


Figure 4.12 Species represented south of, not including, Happisburgh

The prevalence of post-Elsterian *Mammuthus primegenius* (woolly mammoth) is unsurprising, given the widespread occurrence of this species throughout the last glacial period and its dominance in the offshore assemblage overall. This species would not have been contemporary with *Mammuthus meridionalis*, or any of the pre-Elsterian species. Similarly it would not have been associated with

Palaeoloxodon antiquus, the most prolific of the species spanning the glaciation, but could have been associated with *Bison priscus, Bos primigenius, Cervus elaphus, Coelodonta antiquitatis* or *Megaloceros giganteus* (Figure 4.3 and Figure 2.5).

An assemblage containing all the post-Elsterian species would not be uncommon (e.g. Mammoth fauna; Gough's Cave MAZ; Pin Hole MAZ; Currant and Jacobi 2001), nor would an assemblage containing all the pre-Elsterian species (e.g. Breda *et al.* 2010; Lister and Stuart 2010).

Removing the areas with sample sizes of only one, Figure 4.13 shows the changing dominant proportions as you move north to south, moving from assemblages dominated by pre-Elsterian specimens to those dominated by post-Elsterian assemblages. The detail of the specific species is shown by figures 4.11 and 4.12.

The vast majority of the finds from off Happisburgh are due to the prolific local collector Rev. James Layton and his Oyster Bed collection (Layton 1827; Owen 1846). Of the surviving and collated Layton collection, 71% (n=44) are from deposits off Happisburgh, 95% of which are either exclusively pre-Elsterian species (79%, n=35) or existed throughout (16%, n=7), with only 5% (n=2) belonging to the post-Elsterian. The assemblage is heavily dominated by *Mammuthus meridionalis* (63%, n=31), an interglacial species, with 8% (n=4) *Palaeoloxodon antiquus*, also interglacial but present throughout the early Middle – Late Pleistocene, 6% (n=3) *Mammuthus primigenius*, cold stage and seen at the earliest during the latter stages of MIS 8 and decreasing proportions of other species, mostly those that are identified only to genus or are characteristic of the pre-Elsterian period (*Megaloceros savini* and *Rhinoceros etruscus*).

As we move further south to Southwold, the assemblages are dominated by *Mammuthus primigenius* (60%, n=6), with the interglacial, pre-Elsterian species *Mammuthus meridionalis at* 30% (n=3) as well as the post-Elsterian *Bos primigenius* and *Megaloceros giganteus* (both 10%, n=1). Of the 11 specimens within this assemblage 6 of them were collected by Mr J. J. Colman.

Finally, the Tendring Peninsula has 36% (n=15) *Mammuthus primigenius*, 26% (n=11) *Coelodonta antiquitatis* and smaller numbers of *Stephanorhinus hemitoechus* (n=2), *Bos primigenius* (n=1) and *Megaloceros giganteus* (n=1). A dominant proportion of these would fit into a later Pleistocene, cold-stage assemblage, but several (*Megaloceros giganteus*: MIS 11, MIS 5e; *Bos primigenius*: MIS 11, MIS 7) are also, or only (*Stephanorhinus hemitoechus*: MIS 11, MIS 9, MIS 7, MIS 5e, MIS 5c), present during interglacials.

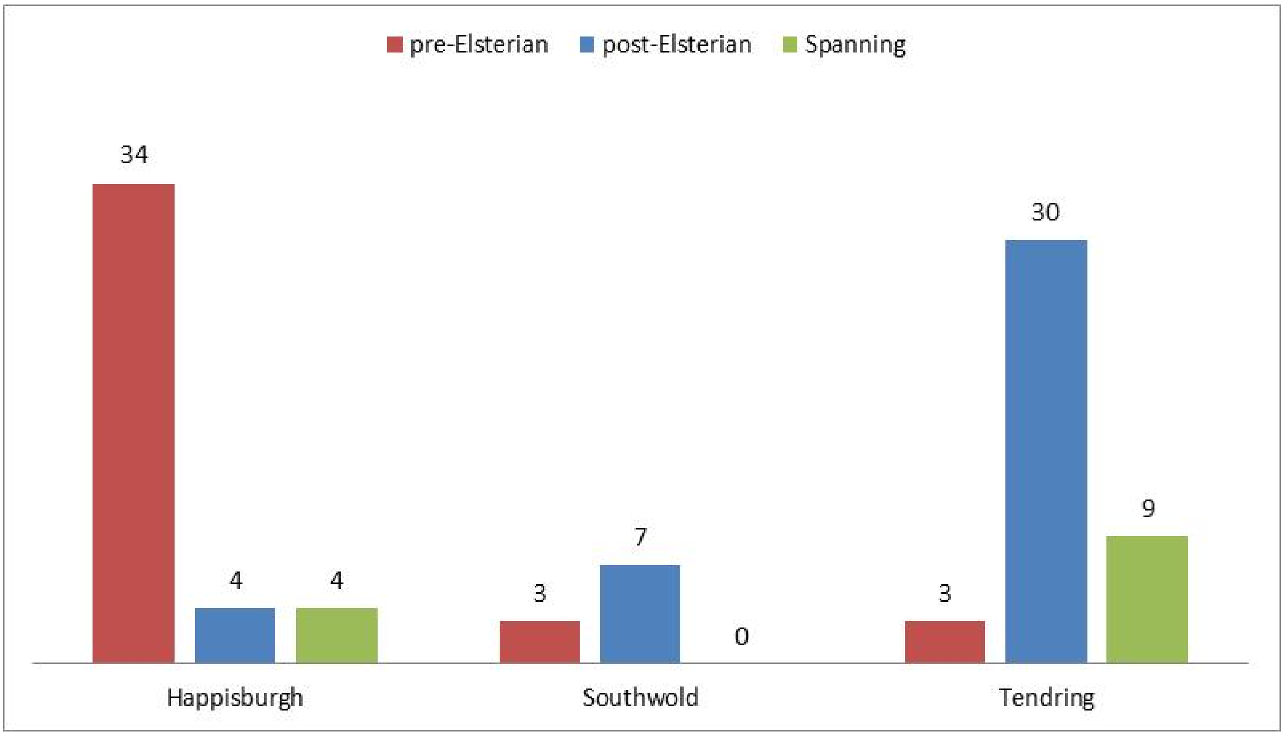


Figure 4.13 Proportions of species moving from north (Happisburgh) to south (Tendring)

The majority of the collection (of those that have been identified to species level [48%, n=15]) from off Tendring comes from Mr. Brand, a local trawlerman, who has collected over thirty years and will be looked at more specifically in an individual case study in Chapter Five. Of the collection off Tendring, 68% are from the post-Elsterian, 7% are pre-Elsterian species and 22% are from species indicative of either (Figure 4.13).

Sea Palling, Clacton, West Runton and Cromer all have only one associated specimen. These sample sizes are clearly too small to be relied on statistically, but combined with the larger samples from Happisburgh, Southwold and Tendring do fit within a trend towards broad spatio-temporal patterning of species as you move from north to south along the coast (Figure 4.10 and 4.13). The pre-Elsterian species appear to be fairly spatially distinct, occurring in the area of known cliff outcroppings and inter-tidal/submerged deposits from just north of Happisburgh to around the level of Sea Palling (Figure 4.14 and 4.15). The post-Elsterian species, on the other hand, dominate towards the south. This implies that the specimens being procured from the seabed are coming up not haphazardly, but from temporally definable Palaeolithic deposits that are potentially intact.

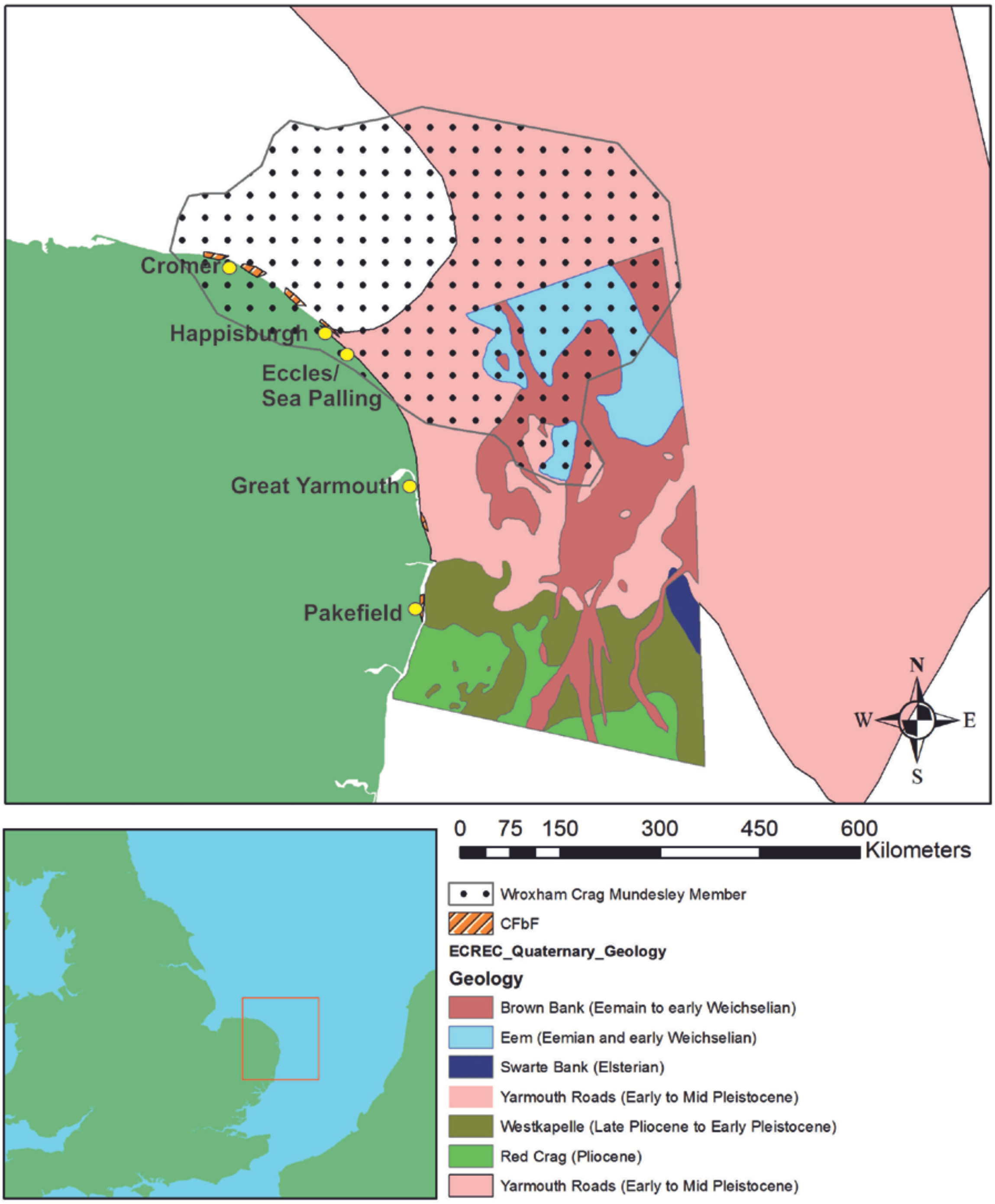


Figure 4.14 Locations of offshore deposits, known cliff/foreshore deposits of the Cromer Forest bed Formation (and Wroxham Crag) and significant locations (after Cameron *et al.* 1992; Rose *et al.* 2001; Robins *et al.* 2008; Limpenny *et al.* 2011)

The deposits around the location of Happisburgh, shown in Figure 4.14 and 4.15, belong to the Cromer Forest-bed Formation (corresponding with the offshore Yarmouth Roads) which is pre-Elsterian, Early to early Middle Pleistocene in date and in many places is formed of a distinctive iron-rich matrix. As far back as 1890, Reid was publishing about blocks of this deposit being washed onto the beach after a big storm on the 30th January 1877, and, as part of a British Geological Survey, attempted to drag for it off a boat, using grapples. Unfortunately although located *"…half-a-mile north-north-east of the Low Lighthouse…"* (Reid 1890, 173) the deposit was too concreted to recover. But owing to the preservation of this deposit offshore and the time-transgressive nature of the CFbF, it is likely that the pre-Elsterian specimens from this area are derived from it.

The dominance towards the south of post-Elsterian species is likely to reflect the general dominance of species from these periods, but given the increased resolution with regard to their locations, allows this to be more accurately refined. For example, the deposits immediately off Clacton, close to where a large proportion of the material comes from (n=342), have been shown to include MIS 11, MIS 9, possibly MIS 7 and MIS 5e (Roe *et al.* 2009; Roe and Preece 2011; Brack *et al.* 2011), but the addition of information from the trawlerman who recovered the bones, as well as geophysical data over that location, should allow us to enhance this further (Chapter Five).

Figure 4.15 Outcropping foreshore deposits of the CFbF (Source: Simon Lewis)

4.2.1.1 The Eccles bone-beds

Discussed above, the area of Sea Palling, immediately to the south of Happisburgh, has only one specimen relating to it and that is of *Mammuthus primigenius* (woolly mammoth). Being a sample size of one, this is not reliable; it is also unexpected given its proximity to the deposits of - and off - Happisburgh. The collection of a large number of specimens from the beach in this area, however, is significant for this research. These specimens have been recovered, often following storms, along a distinct area of coast at Sea Palling by recent collectors as well as historic collectors (the Savin Collection at the NHM). Importantly, the vast majority of these specimens are associated with the iron-rich matrix that characterises the CFbF in this location and have fallen into two pre-Elsterian assemblage types: Early Pleistocene and early Middle Pleistocene (Parfitt pers. comm.).

The collection is very large, with over 1000 specimens, most of which fall into the (late) early Middle Pleistocene group. These include: *Palaeoloxodon antiquus* (straight-tusked elephant), *Mammuthus meridionalis* (southern mammoth), *Mammuthus trogontherii* (steppe mammoth), *Equus ferus* (wild horse), *Stephanorhinus hundsheimensis* (Rhinoceros), *Cervalces latifrons* (Moose), *Hippopotamus* and *Megaloceros* (giant deer). The Early Pleistocene group also includes *Mammuthus meridionalis* (southern mammoth) but includes distinctly Early Pleistocene species such as *Cervalces* cf. *gallicus* (Early Pleistocene elk, present until approximately 1.5ma) and *Microtus sp.* (allophaiomys morphology – no younger than ~1ma). Significantly, the early Middle Pleistocene species, assigned to a late stage within this period (~MIS 15/13) are contemporary with archaeological sites from this Formation (e.g. Happisburgh 1 [Ashton *et al.* 2008a]).

These specimens have not been included within this research's collation as they are from beach contexts. Whilst they are extremely likely to have washed in from the offshore zone (many have marine growth on them), they are not demonstrably from there and so have been only discussed briefly as an addendum to this work. On-going work looking at the onshore – offshore landscapes of Happisburgh will include more work on these specimens (their species characterisation has in fact been a part of that project [Parfitt pers. comm.]), and will be discussed more in the further work section of Chapter Seven.

4.2.1.2 BMAPA

Finds recovered as part of the BMAPA protocol again show the prolific nature of faunal and lithic finds extant in the offshore zone. Figure 4.16 shows these finds plotted for the areas offshore from the East Coast, with recent publications indicating that the recovery of such material is continuing (BMAPA 2013).

The visibility that this project affords these specimens is extremely important for increasing our understanding of the abundance and locations of fossiliferous and implementiferous deposits. Given the nature of the reporting, however, the artefacts themselves are not available for study and so their use as a tool for further research is limited. Furthermore, they represent the record from distinct aggregate deposits which, for economic reasons, will avoid the exploitation of unnecessary materials and thereby limit the type of environments viewed. Nevertheless, as part of a wider issue, the frequency and patterning of finds can be used to highlight high potential areas to target.

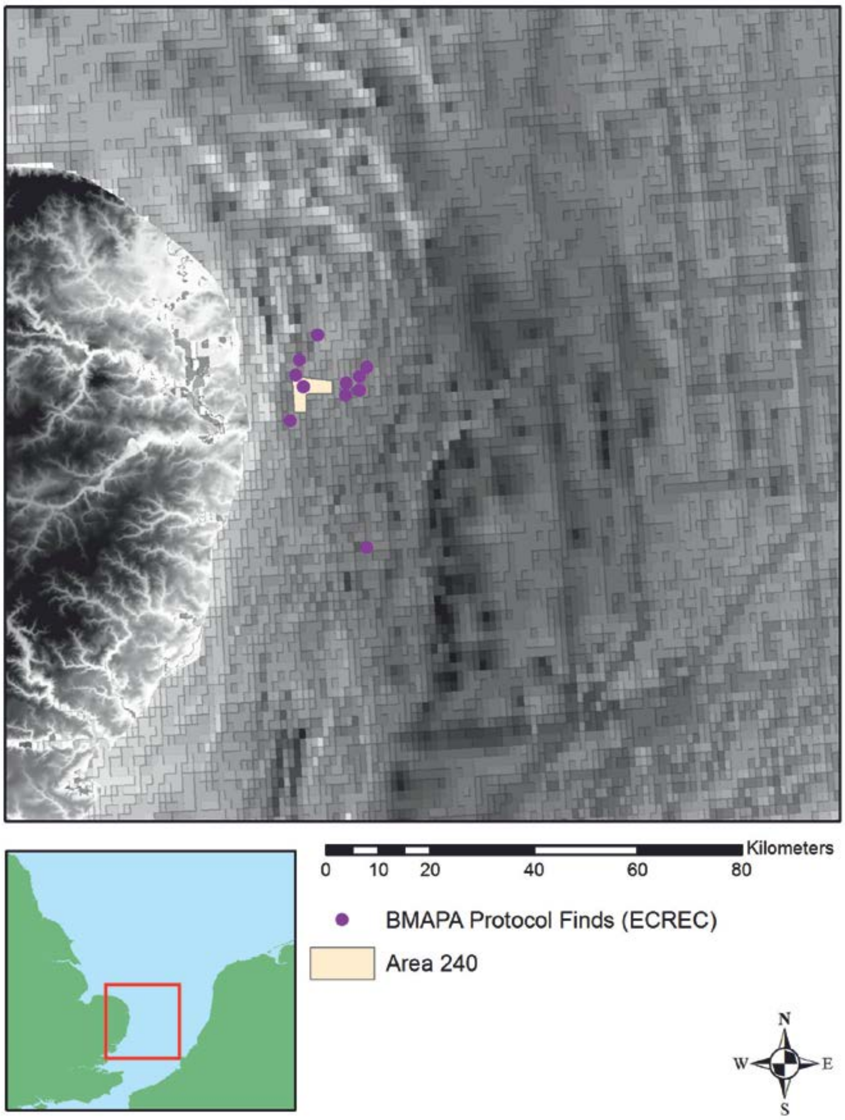


Figure 4.16 Showing find locations from BMAPA as plotted by the East Coast REC project (Limpenny *et al.* 2011)

4.2.2 Offshore Fishing Areas

The majority of the specimens collated relate to larger fishing industries from Great Yarmouth and Lowestoft (Figure 4.9), which, although only 10 miles apart, had significantly different trawling communities (see Chapter Three, Section 3.2).

The former was smaller in size, but far larger in terms of scale, predominantly exploiting areas of and around the Dogger Bank (Figure 3.4), whereas the latter exploited eastern grounds all the way across to the Dutch coast (Figure 3.5).

4.2.2.1 The Great Yarmouth Grounds

There are 52 specimens that are specifically recovered from the Dogger Bank. Based on the understanding of targeted grounds from specific ports, however, taking those labelled as Great Yarmouth as being from the Dogger Bank area increases this sample to 115. In addition, Joseph Owles (Section 3.4) was a prolific collector from Great Yarmouth (which he also printed on his specimens: Figure 4.17) and so his collection of 'East Coast' specimens could be added to this group, which takes the number to 283 (Figure 4.18).

Figure 4.17 Crania from Owles' collection, showing his stamp

The data from this area will initially be presented with Owles' 'East Coast' specimens removed. In this case there are nineteen types of fauna represented, six of which are not identified to species level. The sample size remains at 115 specimens, 64 of which are identifiable to species level and represent 13 species (alternative columns of Figure 4.18).

Within this dataset, there is an abundance of post-Elsterian species (44%, n=51 of the total, 80% of the total without the indeterminate species), *Mammuthus primigenius* in particular (45%, n=29, without indeterminate species included). The pre-Elsterian is represented by 9% (n=10), which are spread mainly between *Cervus polignacus Robert* (a giant deer species, n=4) and *Mammuthus meridionalis* (southern mammoth, n=3). There are only two species which span these periods of the Pleistocene, *Cervus elaphus* (red deer, n=2) and *Equus caballus* (horse, n=1). In addition, the specimens that are indeterminate could be refined further through re-analysis, as can certainly three of the *Elephas sp.* molars.

If we assume that Owles' 'East Coast' specimens are synonymous with the Great Yarmouth grounds, does this pattern hold true? Of the subsequent 283 specimens, there are 25 types of fauna represented, 16 of which have been identified to species level. In total, 39% (n=110) are indeterminate to species level with 52% (n=147) identifiable as post-Elsterian species, 5% (n=15) pre-Elsterian and 4% (n=11) for species spanning early Middle through to Late Pleistocene. Of the indeterminate species at least 32% (n=35) have the potential to be further identified to species level: determining whether specimens have the potential to be defined further relies on the element present. Teeth are easily distinguishable, but many other elements rely on size ranges to be assigned to species, or to minor but very specific morphologies. If we have enough of the bone present to work with, size (which is also variably understood for different species), or a specific part of an element with a distinguishing aspect, is necessary for assignment to be made to species level and will need to be assessed for each of the elements in the dataset. Identifying certain elements further will be a priority for future work.

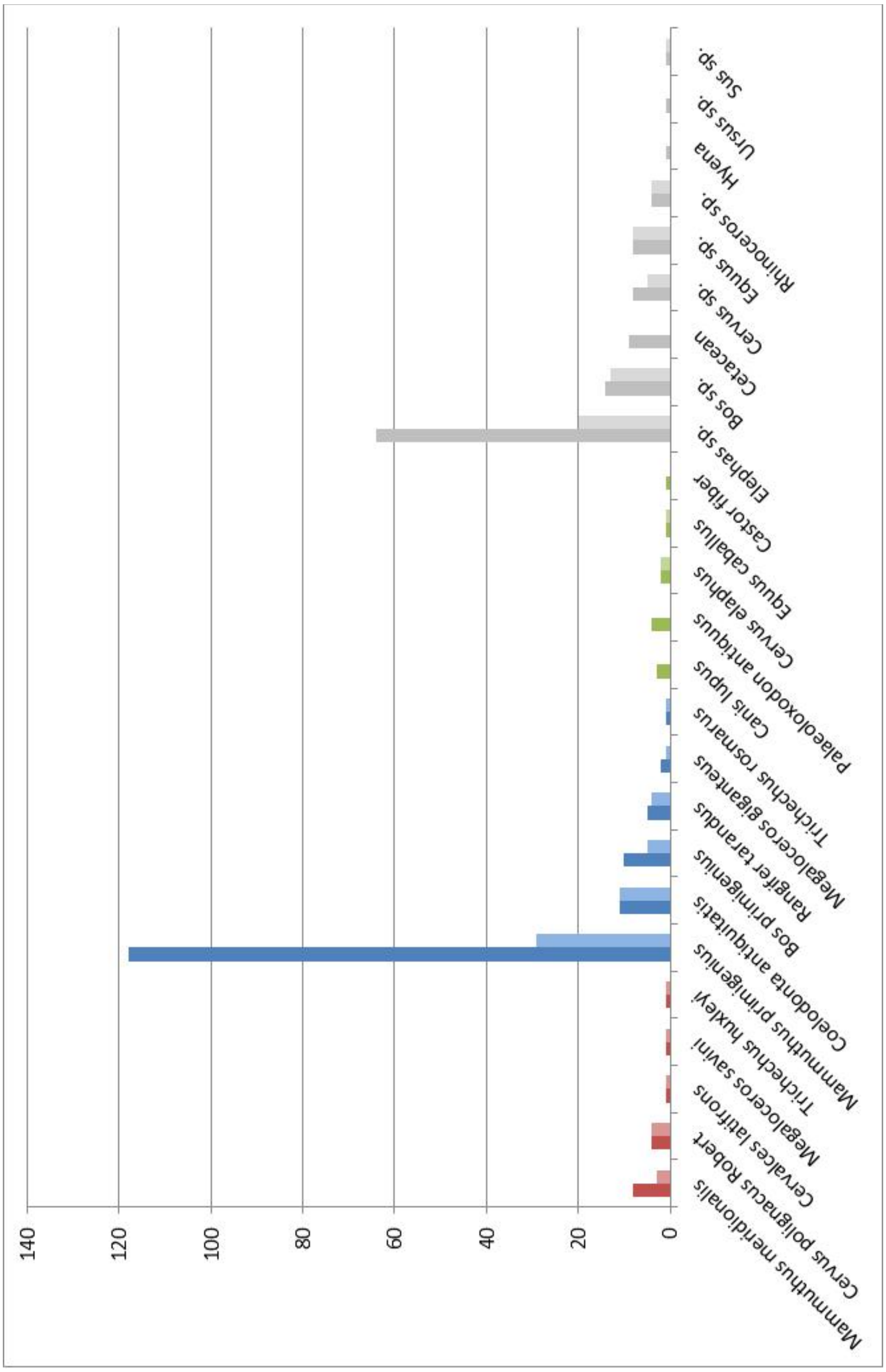


Figure 4.18 Specimens from the Great Yarmouth grounds, showing the inclusion of Owles' collection for each species in the left hand column, as well as it's exclusion in the columns to the right.

As these are currently undistinguishable, however, removing these indeterminate specimens shows a clear dominance of post-Elsterian species, the majority of which (68%, n=118), as usual, belong to *Mammuthus primigenius* (woolly mammoth), with the second and third-most prevalent species belonging to *Coelodonta antiquitatis* (woolly rhino) and *Bos primigenius* (aurochs). In fact all the post-Elsterian species are cold-adapted and commonly associated with one another in later Pleistocene 'mammoth steppe' environments. Similarly, the pre-Elsterian species are all associated with the extensive Cromer Forest-bed Formation, which outcrops along the East Anglian coast and appears to follow into the offshore zone. Interestingly, all of the species that span both these broad periods would sit happily within a Forest-bed assemblage but would also, aside from the interglacial *Palaeoloxodon antiquus* (straight-tusked elephant), not look out of place in the landscapes of the Late Pleistocene.

The pattern of the more parsimonious assemblage is very similar to the more inclusive assemblage but with fewer identified species: not surprising with a smaller sample size. It is clear however that the pattern still holds and this reinforces the interpretation that Owles' collections were from grounds exploited by the Great Yarmouth trawlers.

4.2.3 Lowestoft Grounds: The Galloper to the Ower

The Lowestoft trawlers, having been kept out of the Dogger Bank by dominant Great Yarmouth and north-eastern fleets, exploited grounds to the east of East Anglia along the Norfolk and Suffolk coasts during the winter and over to the coast of Holland during the summer(Figure 3.5; Butcher 1980; Robinson 1996).

There are 174 specimens in this group, with 24 fauna represented, 16 of which are recorded to species level (Figure 4.19). Removing those fauna not identified to species level leaves a total of 93 specimens. Of these, 71% (n=66) are post-Elsterian, 20% (n=18) are pre-Elsterian and 9% (n=8) are species that span both periods.

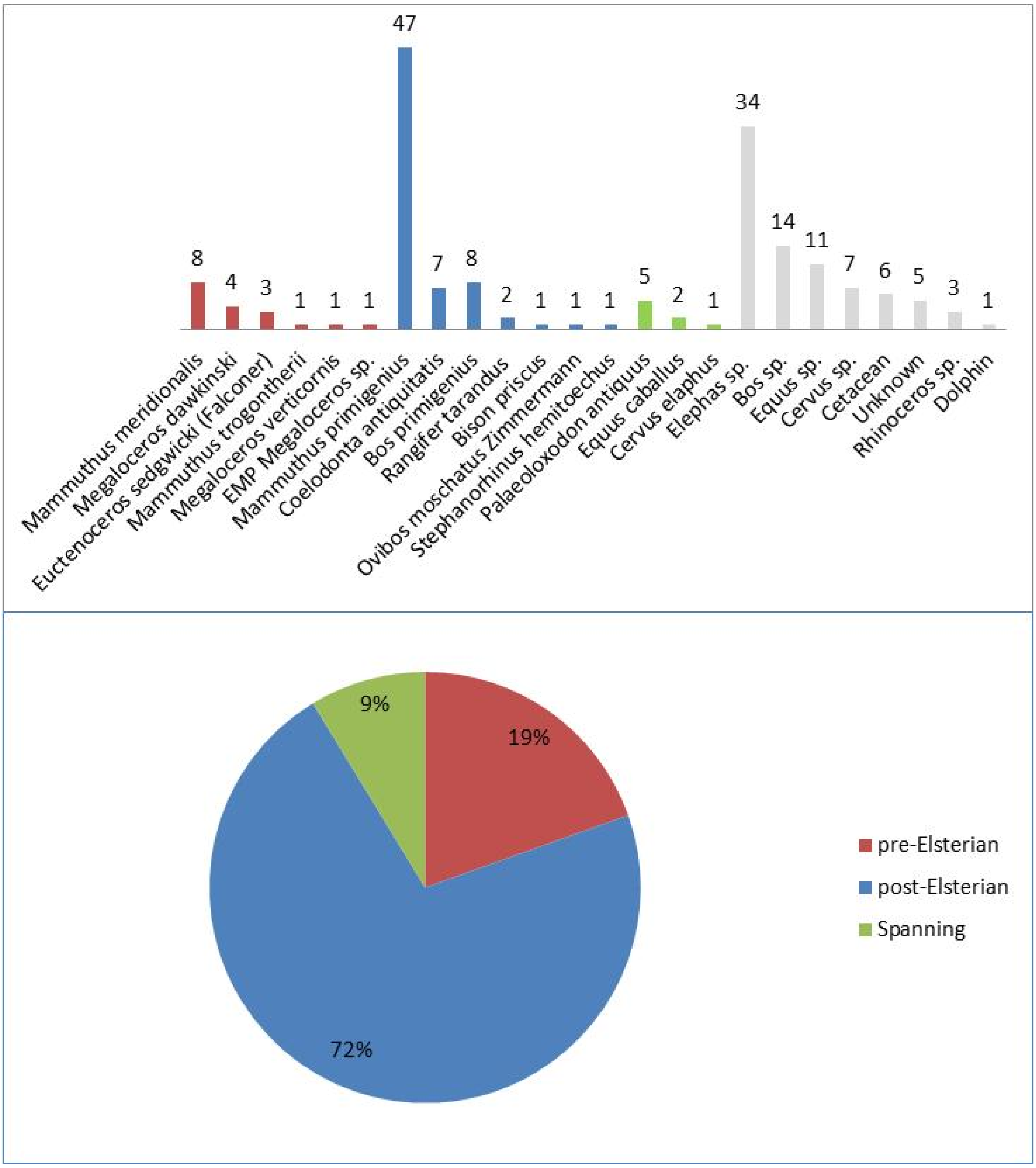


Figure 4.19 Proportions of species from the Lowestoft grounds, with pie chart showing these proportions with the indeterminate specimens removed

The species *Mammuthus primigenius* dominates the assemblage by a large margin at 27% (n=47), or 51% of those identified to species level. With the indeterminate collection of elephant bones also significantly large (20%, n=34), including nine molars that could be clarified to species level with further work, this picture of dominance parallels what is found on and around the Dogger Bank. The one difference with these areas is that the proportion of post-Elsterian species is less than for the Dogger Bank group, which perhaps reflects a relative paucity of extant (or exposed) deposits from this date range.

These more southerly grounds also see the inclusion of, and increase in, Later Pleistocene species that are interglacial in character, for example *Stephanorhinus hemitoechus* (narrow-nosed rhino). *Palaeoloxodon antiquus* has increased numbers relative to the northern grounds, which only have examples of this species with the inclusion of Owles' collection. The smaller-scale, more localised examples from the Tendring Peninsula clearly support this pattern, with six *Palaeoloxodon antiquus* (straight tusked elephant) identified so far as well as two *Stephanorhinus hemitoechus* (narrow nosed rhinoceros), with a large number of rhinoceros and elephant remains yet to be identified to species. The possible presence of hippopotamus further supports this interglacial element.

4.2.4 Dogger Bank

The species represented for the Great Yarmouth grounds are dominated by post-Elsterian species, with all these species fitting into the Late Pleistocene 'mammoth steppe' fauna (e.g. Guthrie 1982; Mol *et al.* 2006). Given that the Great Yarmouth fleets were exploiting the area of and around the Dogger Bank, recent work in this area may help to clarify these patterns.

Spatially extensive 3D seismic data obtained from the oil industry have been used by Gaffney and colleagues to investigate the area from the north Norfolk coast to the Dogger Bank (Figure 4.20, Gaffney *et al.* 2007; 2009), where they have mapped an unprecedented swathe of late Weichselian/Early Holocene landscape. Although the uppermost deposits in this area are predominantly Early Holocene, they overlie (in some areas only to a depth of 1m [Fitch *et al.* 2005]) Late Pleistocene deposits.

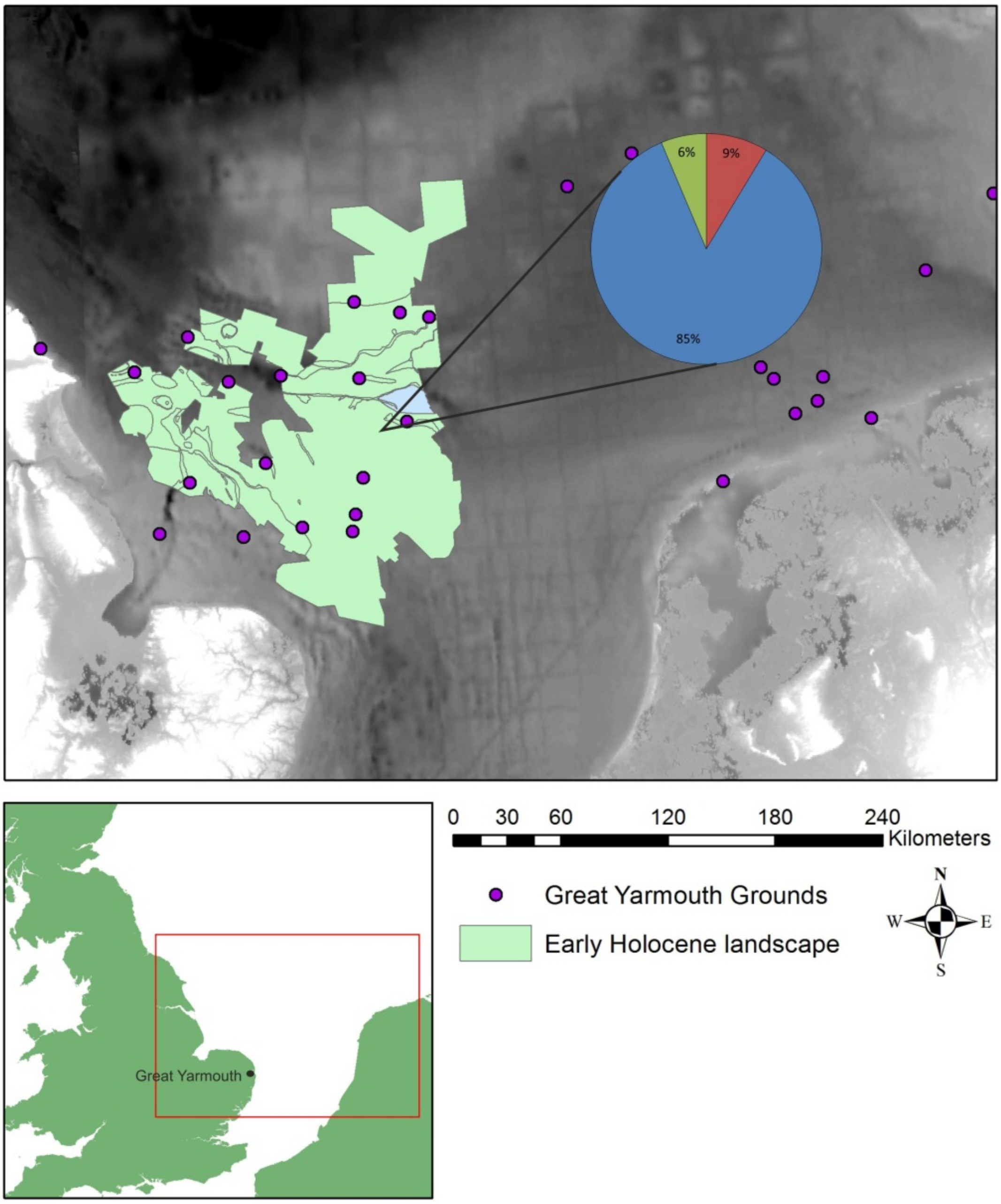


Figure 4.20 Late Weichselian/Early Holocene landscapes (Gaffney *et al.* 2009) with associated fishing grounds. Red box in the insert shows location of main map and the pie chart in the centre of the polygon demonstrates the proportions of pre-Elsterian species (red), post-Elsterian species (blue) and those that span these two periods of the Pleistocene (green).

The dominance of post-Elsterian species across both broad areas of northern and southern grounds exploited by the Great Yarmouth and Lowestoft fleets could indicate a lack of spatial organisation. However, when combined with the above geophysical results this is not unexpected, at least for the Great Yarmouth grounds. Figure 4.20 shows a shapefile of an area of seabed identified as late Weichselian/early Holocene, which corresponds to the areas that these species are being recovered from (Gaffney *et al.* 2009). The increase in numbers of post-Elsterian species in the Dogger Bank area relative to the Lowestoft areas may be explained by this large area of extant deposits. The Lowestoft grounds' avoidance of direct glaciation after the Elsterian (Section 6.1.2), and so potential preservation of more temporally diverse deposits, is another possible reason for this pattern. This is especially so with the Lowestoft trawlers exploiting grounds close to the coastline of East Anglia, where pre-Elsterian deposits are clearly extant (Section 4.2.1).

4.3 Grounds per collector

Given what is known about the various main collectors (Section 3.4 and textboxes therein), what can looking at their individual collections tell us? Their sample sizes will automatically be smaller than the analyses conducted on all of the material from large trawling towns. However, accepting that they were likely to be collecting from a regular set of trawlers may tell us something about the integrity of the deposits at some of the grounds being exploited.

4.3.1 Owles

Owles has 204 specimens in total, 35 of which are from the Dogger Bank and 169 from the East Coast. Since Owles lived in Great Yarmouth all his life, as is printed on many of his specimens (Figure 4.16), it is likely that these were collected from local trawlers fishing on the Dogger Bank and surrounding grounds (Section 3.2.1).

Of the 204 specimens, 134 are identifiable to species level and are dominated by 86% post-Elsterian specimens (Figure 4.21). Only seven specimens out of the entire collection are pre-Elsterian with five *Mammuthus meridionalis*, and one of each *Megaloceros savini* and *Cervalces latifrons* (extinct deer species). These may represent one of three things: remains from an extant deposit, a background 'noise' of loose specimens (Section 3.4) or, possibly, the result of ad hoc trawling on pre-Elsterian deposits on their way back into Great Yarmouth (e.g. Section 3.2.1).

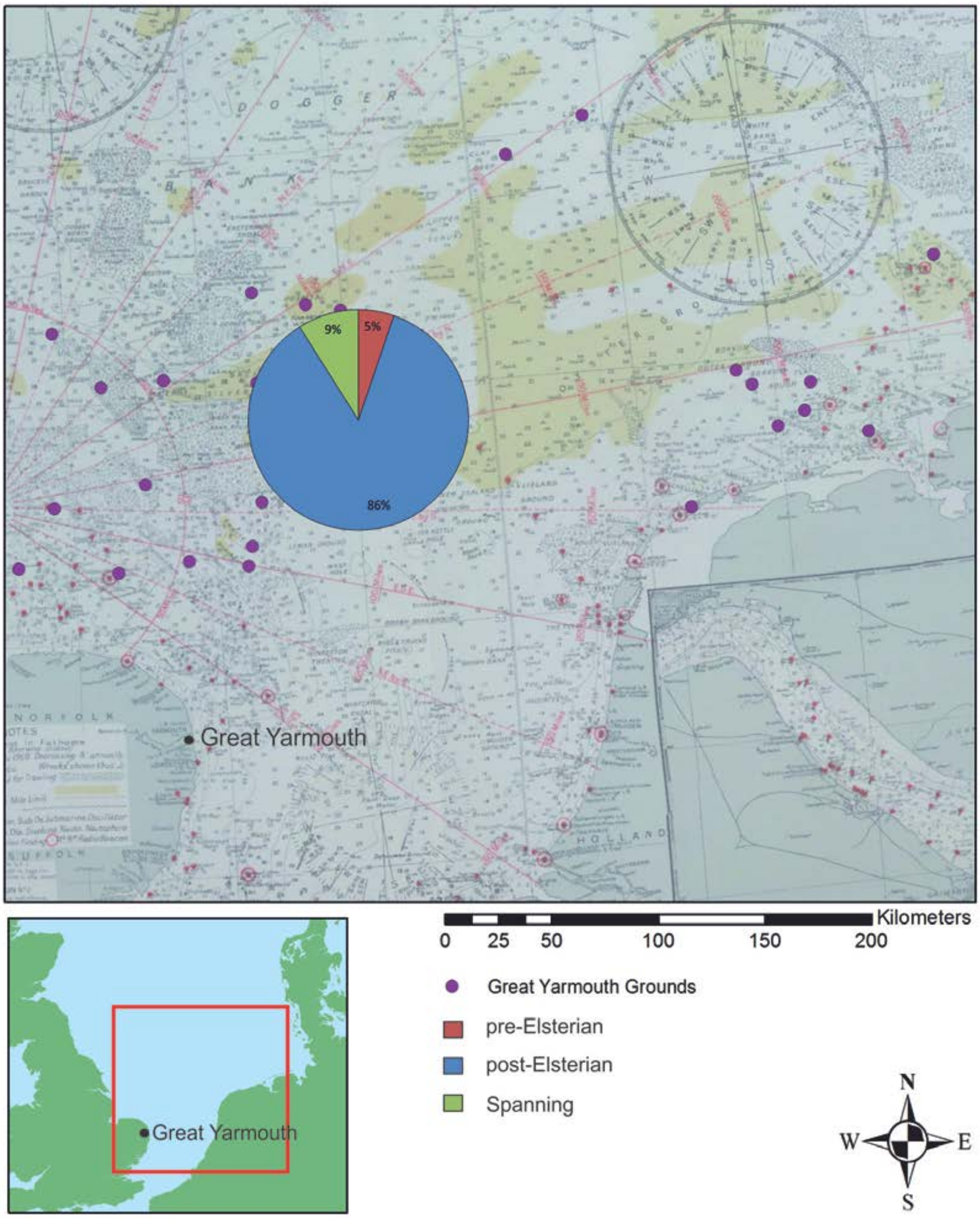


Figure 4.21 Owles' home and collection locations

4.3.2 Gunn Collection

Living at Irstead but collecting half of his specimens from Great Yarmouth and half from 'off Norfolk', Gunn may display in his collection specimens from smaller-scale local deposits as well as those from the Dogger grounds.

Figure 4.22 shows the proportions of these species from each area, with the pie chart over the Dogger grounds displaying finds from Great Yarmouth and the chart to the south displaying results from the grounds 'off Norfolk'.

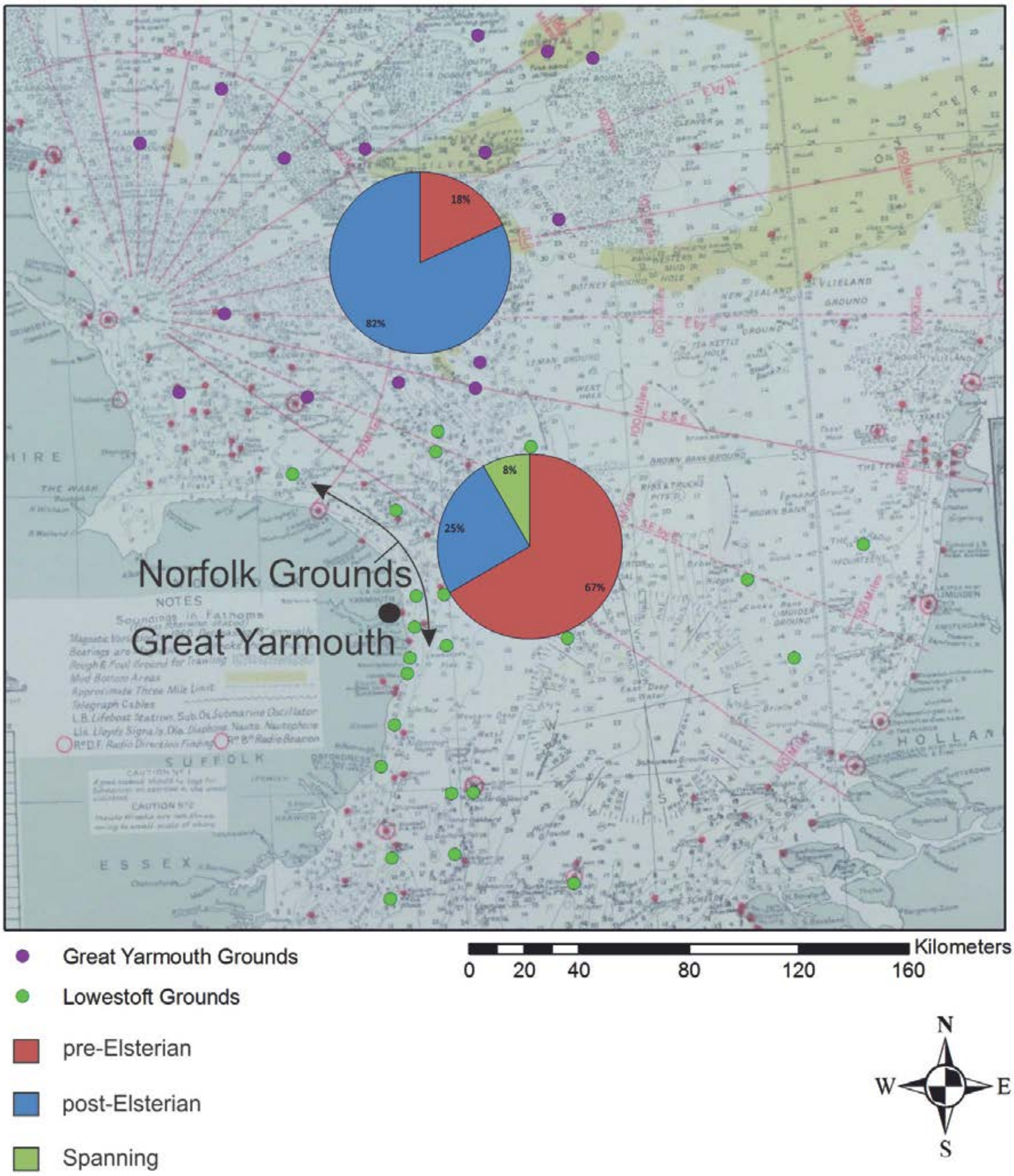


Figure 4.22 Gunn's home and collection locations

The Great Yarmouth specimens are dominated, once again, by post-Elsterian species at 82% (n=9), compared with a dominance of pre-Elsterian species from the Norfolk grounds at 67% (n=8), possibly reflecting the trawling of pre-Elsterian CFbF deposits off the Norfolk coast compared with Later Pleistocene deposits further to the north.

4.3.3 Jeremiah James Colman

J. J. Colman's collection is made up of specimens from grounds off Norfolk and out of Lowestoft, local Southwold grounds, a few 'North Sea' and one Great Yarmouth specimen (which is an indeterminate *Elephas sp.*).

The collection from deposits near Southwold is 100% post-Elsterian (n=6) with five *Mammuthus primigenius* (woolly mammoth) and a *Bos primigenius* (Aurochs). The *Mammuthus primigenius* remains demonstrate a date for these specimens that is, at the earliest, late MIS 8 (Figure 2.5). Similarly, the specimens off Lowestoft are also dominated by post-Elsterian species, at 94% (Figure 4.23).

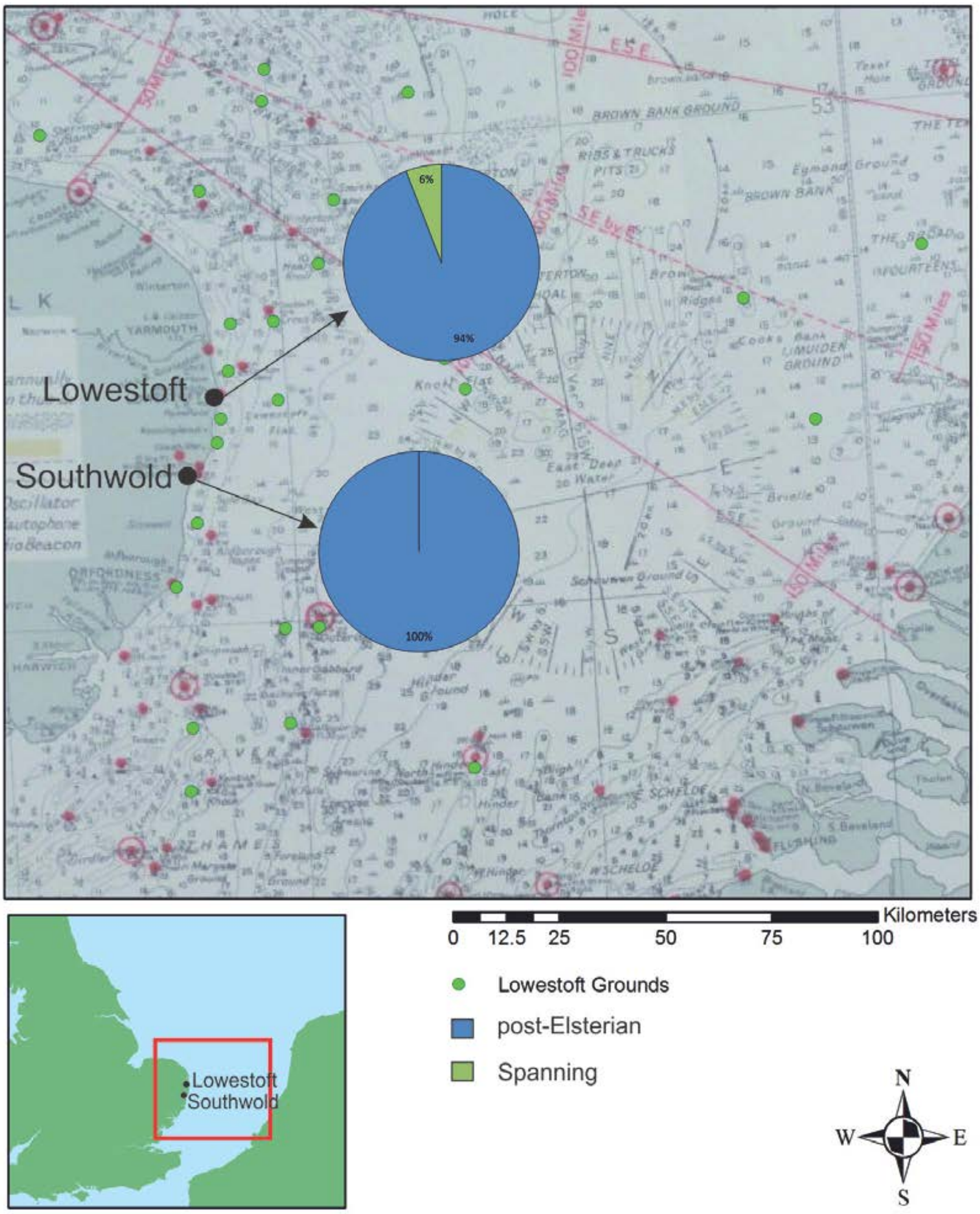


Figure 4.23 J.J.Colman's home and collection location

4.3.4 Layton's collection

Layton collected his offshore material almost entirely from the oyster dredgers working out of Happisburgh on what is almost certainly a local deposit (Section 4.2.1, 4.5.3, 3.1). His specimens which are from the 'East Coast' (n=19) are 63% (n=12) cetacean and the remainder are not identified to species. Forty-two out of forty-six of his remaining specimens are identified to species, with 83% (n=35) of these being pre-Elsterian (Figure 4.24)

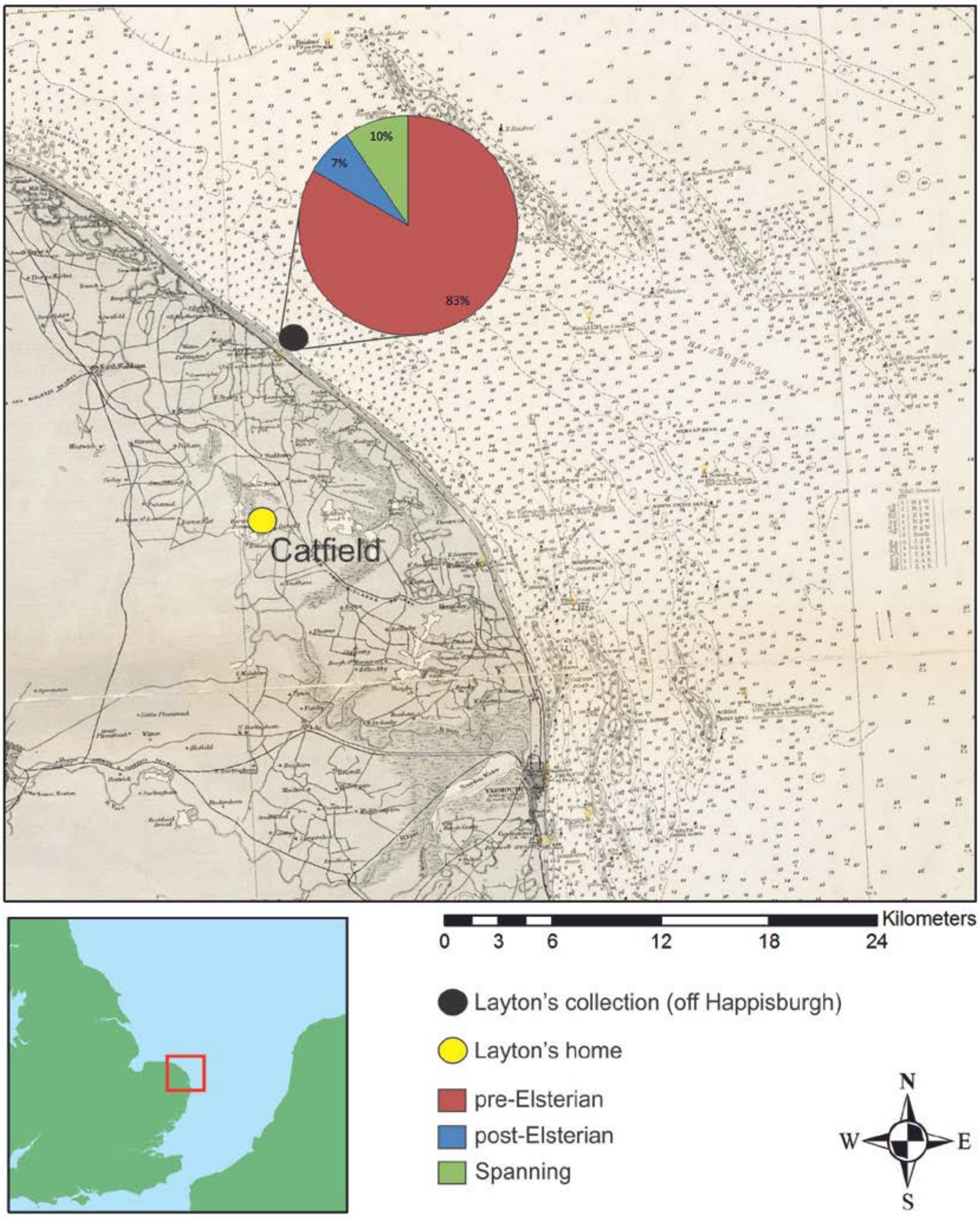


Figure 4.24 Layton's home and collection location

4.3.4.1 Antiquarian patterns

The patterns of the results for each collector, which have, to a large degree, been collected from the same grounds, demonstrate temporal trends. There are no collections that display a wide variety of species, but, instead, each collection tends to group towards either Later Pleistocene species, or those from the pre-Elsterian. Reflecting the broader patterns, the majority of the collector's material is from the later Pleistocene, with Layton's collection being the only one to be dominated by pre-Elsterian material. It seems reasonable to assume that this reflects a good degree of integrity to the bone-yielding deposits being disturbed from each area.

4.4 Dutch comparisons

Table 4.2 lists the species being trawled from the locality of the Eurogeul (the shipping lane into the port of Rotterdam [Mol *et al.* 2006]) and which are commonly associated with the Late Pleistocene 'mammoth fauna' (Guthrie 1982; Vereshchagin and Baryshnikov 1982)

Proboscidea
Mammuthus primigenius—woolly mammoth
Artiodactyla
Bison priscus—bison
Ovibos moschatus—musk ox
Rangifer tarandus—reindeer
Megaloceros giganteus—Irish elk
Alces alces—moose
Cervus elaphus—red deer
Perissodactyla
Equus caballus—horse
Coelodonta antiquitatis—woolly rhino
Carnivora—Fissipedia
Ursus arctos—brown bear
Crocuta crocuta—hyaena
Panthera spelaea—cave lion
Canis lupus—wolf
Carnivora—Pinnipedia
Phocidae
Pagophilus groenlandica—harpseal
Pusa hispida—ringed seal
Odobenidae
Odobenus rosmarus—walrus
Cetacea—Odontoceti
Monodontidae
Delphinapterus leucas—beluga
Delphinidae
Orcinus orca—killer whale
Cetacea – Mysticeti
Eschrichtidae
Eschrichtius robustus—gray whale

Table 4.2 A typical mammoth fauna (after Mol *et al.* 2006 [Table 3]): fauna from the Eurogeul locality

The parallels between the species being recovered by Dutch researchers (van Kolfschoten *et al.* 1995; Mol *et al.* 2004; Glimerveen *et al.* 2004) and those dominating the offshore trawling grounds from the UK sector are interesting. The Dutch researchers' relationship with their modern trawling industry are extremely well developed so they are able to pinpoint where individual finds that are being currently recovered come from on the seabed (Figure 4.25; van Kolfschoten *et al.* 1995; Glimerveen *et al.* 2004; Mol *et al.* 2006). This is in addition to the work being conducted on the dredged shipping land into and out of the Eurogeul, producing a fine-grained case study of the submerged deposits from this location (Glimerveen *et al.* 2004; Mol *et al.* 2006).

The Brown Bank, a favoured ground for the Dutch trawlers (and one exploited by the Lowestoft trawlers during the summer: Section 3.2.3), appears to be heavily dominated by Late Pleistocene 'mammoth fauna' material, 17 of which have been radiocarbon-dated to this period (Table 4.3, Mol *et al.* 2006). Given the length of time this faunal assemblage could have been present in this broad area (From MIS 5d until after the Last Glacial Maximum, so approximately 100kys [Lambeck *et al.* 2002; White and Schreve 2001; Hijma *et al.* 2012]), and the fact that, although sea levels would have been dynamic, the associated deposits would have been subjected to only one major glacial period and its associated effects, the dominance of these species relative to those of earlier periods is not surprising.

Radiocarbon dates on mammal bone from the Brown Bank locality in the North Sea		
Mammuthus primigenius, metacarpal IV dext.	Tuscon Az 17634[a] DG fieldnumber 412	33,800±1200BP
Mammuthus primigenius, M3 inf. dext.	Tuscon Az 17645[a] DG fieldnumber 423[b]	35,200±2000BP
Mammuthus primigenius M3 inf. dext.	Tuscon Az 17643[a] DG fieldnumber 421[b]	>36,200BP
Mammuthus primigenius M3 sup. sin.	Tuscon Az 17647[a] DG fieldnumber 425[b]	36,800±2400BP
Mammuthus primigenius, M3 sup. dext.	Tuscon Az 17642[a] DG fieldnumber 420[b]	37,900±2800BP
Mammuthus primigenius, atlas	Tuscon Az 17637[a] DG fieldnumber 415[b]	39,800±3400BP
Mammuthus primigenius, M3 sup. dext.	Tuscon Az 17648[a] DG fieldnumber 426[b]	>38,600BP
Mammuthus primigenius, lunatum dext.	Tuscon Az 17638[a] DG fieldnumber 416[b]	>38,900BP
Mammuthus primigenius, fibula dext.	Tuscon Az 17636[a] DG fieldnumber 414[b]	>39,000BP
Mammuthus primigenius, triquetrum dext.	Tuscon Az 17639[a] DG fieldnumber 417[b]	>39,300BP
Mammuthus primigenius, axis	Tuscon Az 17635[a] DG fieldnumber 413[b]	>40,000BP
Mammuthus primigenius, M3 sup. dext.	Tuscon Az 17640[a] DG fieldnumber 418[b]	>41,100BP
Mammuthus primigenius, axis	GrA 11640[c]	>45,000BP
Crocuta crocuta, ulna	GrA 11643[c]	40,660±350-300BP
Ovibos moschatus, metacarpal	GrA 11641[c]	36,740±230BP
Ovibos moschatus, metacarpal	OxA 6307[d]	35,600±1200BP
Megaloceros giganteus, metacarpal	OxA 6308[d]	36,300±1100BP

Abbreviations used: dext. = dexter (right); sin. = sinister (left); inf = inferior (lower); sup. = superior (upper).
[a]Tuscon, Arizona AMS radiocarbon dating
[b]With acknowledgement to Dr. R. Dale. Guthrie (=DG), Fairbanks, Alaska
[c]Groningen AMS radiocarbon dating
[d] Oxford University, Research Laboratory for Archaeology and the History of Art AMR Radiocarbon Dating

Table 4.3 from Mol *et al.* 2006. Radiocarbon dated bones from the Brown Bank locality.

The locations where Dutch trawlers throughout the 1960s-80s were recovering large quantities (>100) of remains are shown in Figure 4.25. These remains span the Early to Late Pleistocene but are dominated by early Middle and Late Pleistocene, with only a few Early Pleistocene species found (*Mammuthus meridionalis* and *Anancus arvernensis*, both early forms of mammoth [van Kolfschoten and Laban 1995]). The accuracy of the points, or how they were arrived at, is not known, nor is the association of species with specific points. However, the similarities with the UK data are striking, with a dominance of *Mammuthus primigenius,* good representation pre-Elsterian species, a very good representation of Late Pleistocene species and a scarcity of carnivore remains (cf. Remuer *et al.* 2003; Mol and van Logchem 2009).

It is suggested that this species patterning may be due to the presence of Pleistocene outcroppings underneath (and therefore between) sand banks in this part of the southern North Sea, especially in the deeper water channel shown in purple in Figure 4.25.

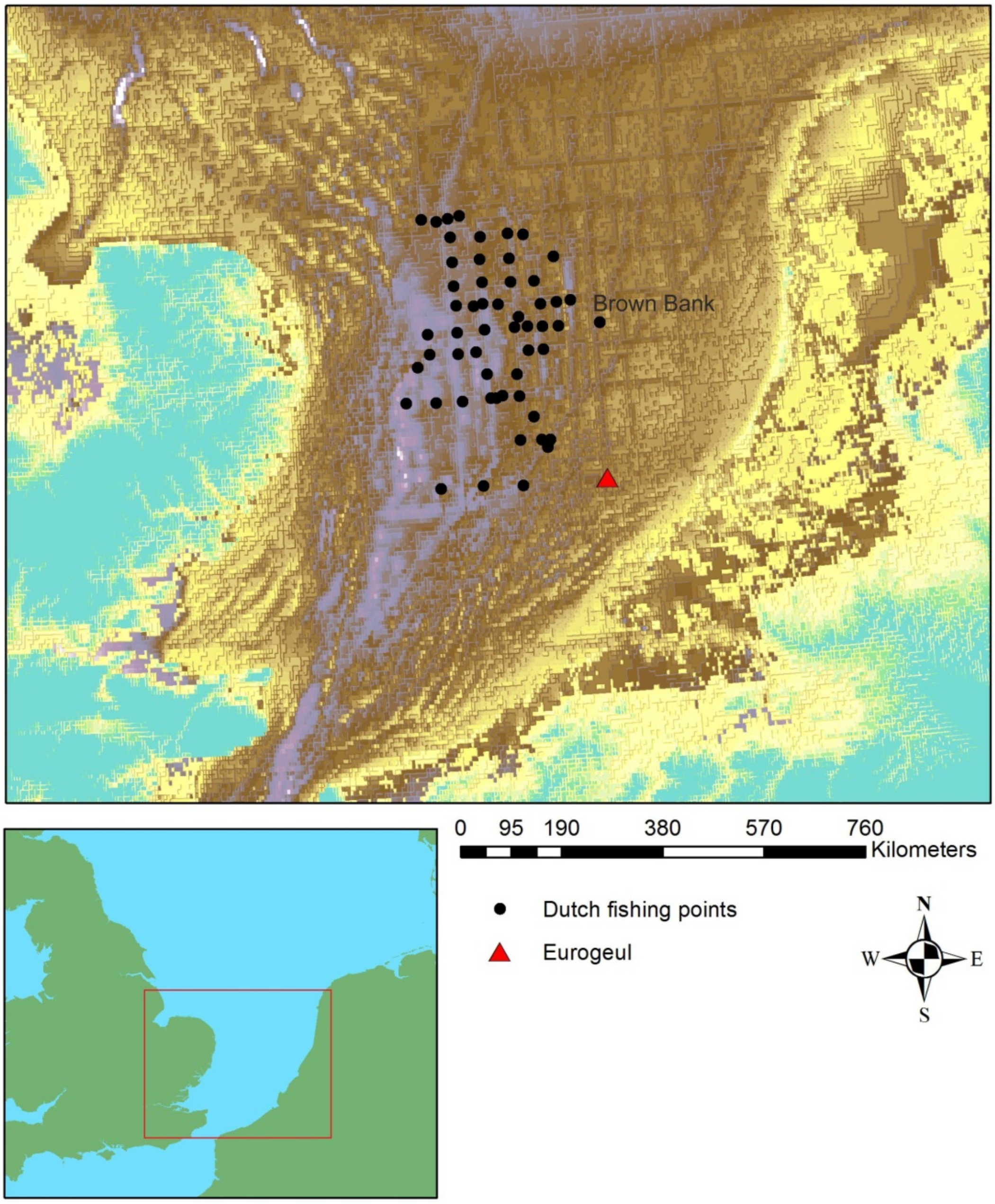


Figure 4.25 Points at which Dutch fishermen have retrieved fauna from 1960s until 1990s, also showing the location of the Eurogeul and the Brown Bank (after van Kolfschoten and Laban 1995; Mol *et al.* 2006).

The Lowestoft trawlers during the 19th Century would have been exploiting the seabed in a similar locality to the areas the Dutch trawlers are working now, although with the addition of a far wider scope of grounds (Figure 3.5). Table 4.4

shows the cross-over with the species recognised from the Dutch lists and the Lowestoft lists. Whilst there is only a 42% cross-over, these include the prevalent species such as all three mammoths, *Palaeoloxodon antiquus, Coelodonta antiquitatis* and *Cervus elaphus*. The differences between the datasets appear to be a greater distinction of species (e.g. three types of horse recognised) within the Dutch list. This is probably because this study was made by a faunal specialist (van Kolfschoten), and because of the presence of several CFbF-specific species (Megacerine deer species) with the Lowestoft list.

Species	**Dutch lists**	**Lowestoft lists**
Alces alces (moose)	*	
Bison priscus (Bison)	*	*
Bos primigenius (aurochs)	*	*
Canis lupus (grey wolf)	*	*
Capreolus capreolus (roe deer)	*	
Castor fiber (European beaver)	*	*
Cervus elaphus (red deer)	*	*
Cervalces latifrons (moose)	*	
Coelodonta antiquitatis (woolly rhino)	*	*
Crocuta crocuta (spotted hyaena)	*	
Equus bressanus (horse)	*	
Equus caballus (horse)	*	*
Equus hydruntinus (horse)	*	
Eutenoceros sedgwicki (giant deer)		*
Hippopotamus antiquus (hippopotamus)	*	
Lutra lutra (eurasian otter)	*	
Mammuthus meridionalis (southern mammoth)	*	*
Mammuthus primigenius (woolly mammoth)	*	*
Mammuthus trogontherii (steppe mammoth)	*	*
Megaloceros dawkinski (giant deer)		*
Megaloceros giganteus (giant deer)		*
Megaloceros verticornis (giant deer)		*
Ovibos moschatus (musk ox)	*	*
Palaeoloxodon antiquus (Straight tusked elephant)	*	*
Panthera leo (lion)	*	
Rangifer tarandus (reindeer)	*	*
Stephanorhinus etruscus (early rhino)	*	
Stephanorhinus hemitoechus (narrow nosed rhinoceros)		*
Sus scrofa (wild boar)	*	
Ursus arctos (brown bear)	*	
Ursus spelaeus (cave bear)	*	

Table 4.4 Comparison of Dutch with Lowestoft lists, showing species occurring within both in blue (Dutch data after van Kolfschoten and Laban 1995)

The Dutch comparison, using modern trawlers, demonstrates the potential for pinpointing ever more direct parts of the seabed when fishermen are available to work with and modern GPS techniques can be used. Whilst the species lists are not refined to specific areas, the potential is clearly there, but this will require the development of relationships with current trawling communities.

The association of species from this area with the known location of both early Middle and Late Pleistocene deposits lends weight to the hypothesis that these specimens are deriving from intact seabed deposits. The implications that this has for the Palaeolithic are substantial, as it indicates that fragments of Palaeolithic landscape are still preserved.

4.5 **Ecologies**

Having talked about the fauna with respect to broad seabed locations and the range of time periods that they may represent, it is also necessary to highlight them as broad-scale ecological markers. In this way they are able to shed light on the types of environments that they derive from, be it, for example, interglacial, periglacial, open or wooded and, in turn, whether these are likely to be related to high- or low-stand periods.

Given the vast time-span of this research, few species within the collection are indicative of a definite period of time but several are present throughout, such as *Cervus elaphus* (red deer) and *Palaeoloxodon antiquus* (straight-tusked elephant). In addition, the majority of the species are present throughout at least several MI stages, as indicated by Figure 2.5, making their attribution to various ecologies potentially useful for their further refinement.

The results presented indicate a prevalence of low-stand, cold-stage (and hence post-Elsterian) species relative to those representing high-stand interglacials. This is potentially to do with the availability of the terrestrial land throughout post-Elsterian and the difference in its morphology during high-stand versus low-stand periods; its implications will be discussed further within Chapter Six.

4.6 Lithic Results

With no lithics recovered from the offshore trawling industry, a brief analysis of those from beach locations has been carried out. Table 4.5 shows the 152 lithics collated from foreshore or beach locations. The collection is dominated by flakes but with 38% (n=57) handaxes which is likely to be due to the inclusion of the results from the (exclusively) handaxe focused paper by Robins *et al.* (1998).

Site	Core	Flake	Handaxe
Aldeburgh	0	1	0
Area 240	1	1	4
Arwarton	0	0	1
Bacton	0	0	1
Bawdsey	0	30	1
Benacre	0	0	1
Casiter on sea	0	0	2
Clacton on sea	0	0	1
Cley next the sea	0	1	0
East Mersea	0	0	1
Eccles Cart Gap	0	2	0
Felixstowe Ferry Beach	0	11	2
Great Yarmouth beach	0	0	1
Happisburgh beach	3	16	10
Harwich	0	0	1
Herne Bay	0	0	1
Hopton on Sea	0	0	1
Horsey Beach	0	0	7
Happisburgh site 1	0	2	0
Lessingham	0	1	5
Mundesley Besch	0	1	0
Overstrand	0	2	1
Pakefield	0	1	0
Sea Palling	0	1	7

Sherringham	1	0	0
Shotley	0	0	1
Sidestrand	0	1	4
West Mersea	0	14	0
West Runton	2	3	3
TOTAL	**7**	**88**	**57**

Table 4.5 showing the frequency of lithic-types at locations

The lithic finds that were collated from beach and foreshore locations have been plotted to look at clusters of this material. Figure 4.26 shows the bulk of the material clusters at, and to the south of, an outcropping of CFbF near Happisburgh. This correlates with the dominant direction of shoreline current in that area and may indicate movement of the lithics by long-shore drift (Vincent 1979). There have also been a series of sea defences created just to the south of Happisburgh at Sea Palling which may be influencing the movement of material from the immediately offshore zone onto the beaches, or further down-current.

Questions therefore arise whether these lithics are washing in from offshore, or simply being eroded from existing cliff deposits. The cliff and foreshore deposits to the south of Sea Palling (c.7km south of Happisburgh) are largely Holocene, so any Palaeolithic stone tools in these locations are likely to be intrusive, having been transported from further to the north (although see the two outcroppings of CFbF deposits south of Great Yarmouth). The patterns of sediment transport in this area are currently being explored to further inform this work (e.g. Thomalla & Vincent 2003; Nicholls *et al.* 2012).

This work provides a baseline understanding of the lithics in this area, with much work to be done on forming an understanding of their provenance and movement. Synchronous and on-going work by researchers at the Natural History Museum and British Museum is developing this picture further, as well as integrating it with some specific faunal remains from the beaches in this area.

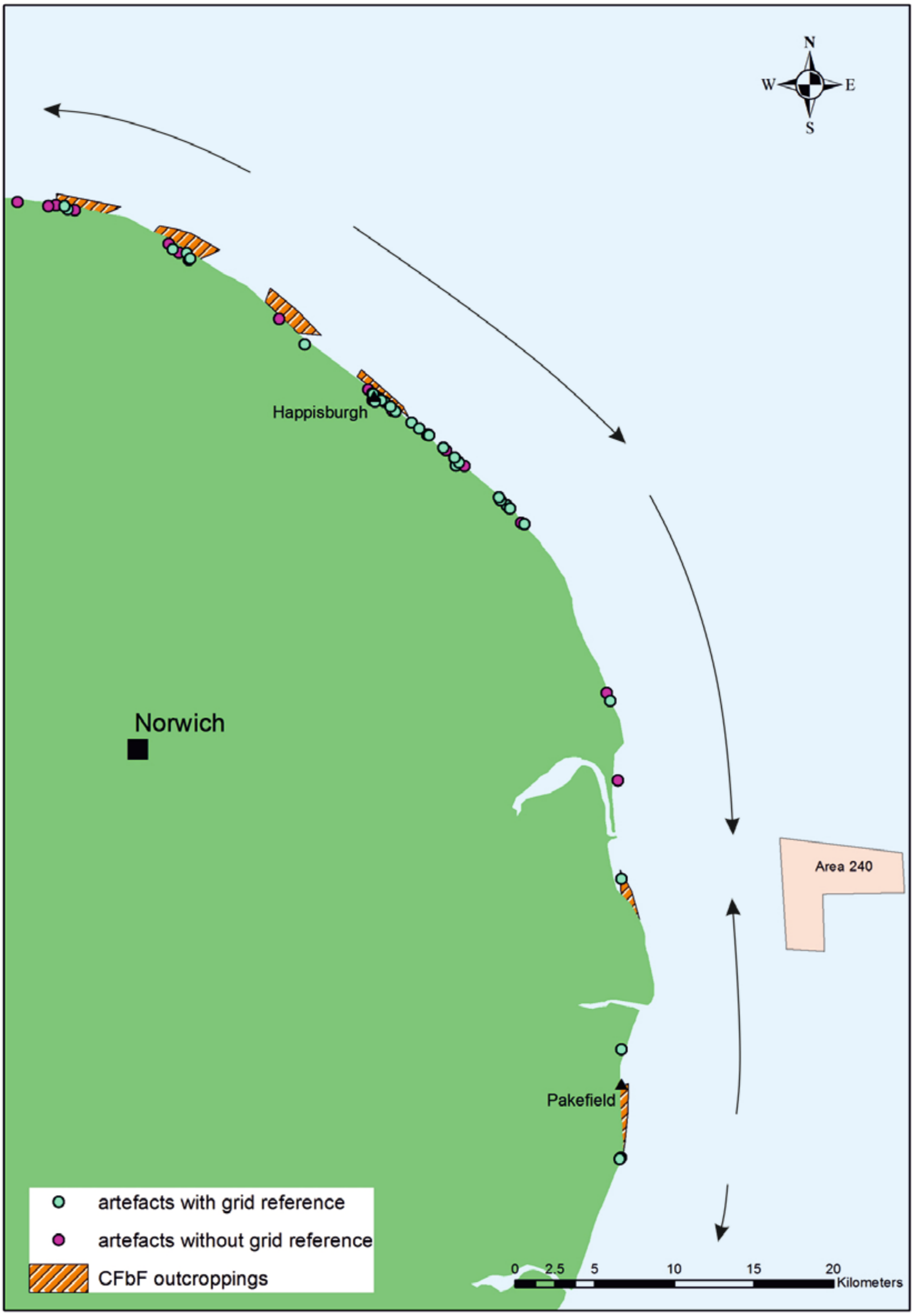


Figure 4.26 Clustering of lithic artefacts along the coast of East Anglia, with arrows showing dominant current direction (CFbF and current info after Vincent 1980; Robins *et al.* 2008).

4.7 Discussion

This chapter has applied the methods developed in Chapter Three to the 1,119 specimens recovered from the southern North Sea since the early 19th Century. Generally overlooked or considered without use, these results have now demonstrated that there is a significant amount of information that can be derived from this material. They have also highlighted the limitations of the record as well as areas where more work would be beneficial.

Returning to the questions posed in Chapter One:

- *What is the nature of these specimens and the deposits they are contained within?*
- *What do their distribution and patterning tell us about the offshore resource?*

What can now be said?

4.7.1 The nature of the specimens

The specimens recovered are made up of a variety of element types and sizes, representing all parts of the skeleton, but with a definite dominance of identifiable elements such as teeth and vertebrae. This is likely to reflect collector preference in terms of element but also potentially collector and trawler preference in terms of size, with bones such as mammoth humeri taking up far more room on board vessels and much less easy for a dock-side collector to transport.

In terms of the species found, there are several interesting patterns that can be observed. There is a clear dominance of post-Elsterian species, with a high proportion of unidentified *Elephas sp*. (mammoth) remains. This holds true throughout the southern grounds as well as those to the north on and around the Dogger Bank.

The dominance of *Mammuthus primigenius* (woolly mammoth) is unsurprising given their size, from the perspective of preservation as well as recovery. This species were present from late MIS 8 and through all subsequent cold stages (later MIS 5, MIS 4, MIS 3 and MIS 2 [Currant and Jacobi 2001; Schreve 2001]), and most iconic during the cold stages of the Weichselian (MIS 5d – 2, c.110ka – 10ka). Given its recent occurrence in North Western Europe, its dominance in the record relative to species that went extinct earlier in the Pleistocene is to be expected; although these earlier deposits do exist, they are likely to be more fragmented than those formed during the Weichselian, as they have undergone a higher number of destructive periods of trans- and regression as well as glaciation.

The high numbers of *Rhinoceros sp.* remains, and relatively high numbers of *Coelodonta antiquitatis* (woolly rhinoceros) so far identified, makes sense from the perspective of timescale but is still an unusual picture. *Coelodonta antiquitatis* are (so far) only recognised from the British record in MIS 8, late MIS 7 and MIS 3 and, for example, their prevalence at Lynford is very low, forming only 1.3% of the faunal assemblage (Smith 2012). It is noted by Mol (*et al.* 2006) that the abundance of this species in the deposits from the Brown Bank are unusually high, more so than any other area of Eurasia, which is a picture supported by this research. This leads to the question: does this have something to do with the ecologies of these areas during the Late Pleistocene being particularly attractive for this species? This is a question that will be returned to in the discussion of Chapter Six.

The patterning identified for the broader offshore areas, both out of Lowestoft as well as Great Yarmouth, are the dominance of post-Elsterian species. Combined with a scarcity of species indicating interglacial conditions (such as *Palaeoloxodon antiquus* [straight tusked elephant] or *Stephanorhinus hemitoechus* [narrow-nosed rhinoceros]), it is likely that this pattern is due to the palaeogeography and associated sea levels of the southern North Sea throughout the Pleistocene (e.g. Figure 2.3 showing a lack of extensive terrestrial deposits in the southern North Sea after the Elsterian interglacial). As touched on in Section 4.4, Chapter Six will look at the combination of these remains with known seabed geology in order to explore these ideas further and to address the second part of the first question, the nature of the deposits.

4.7.1.1 Higher resolution patterns

Evidence from smaller-scale areas closer to the coastline is easier to interpret, since we know that these locations were likely to have been exploited by smaller, local boats, launched from the beach (Section 3.2.1). In terms of spatial refinement, the collection from these areas is made up of two types of data - modern and historic - with the modern data being generally more spatially accurate than the historic, if only because the collector is still alive to speak with. Both types of data, however, have provided examples of higher-resolution areas which can be further investigated. Results from these areas show a definite distinction between, for example, the locations of Happisburgh and the Tendring Peninsula (Fig 4.13).

Although several other locations have been identified with an extremely small number of specimens, both Happisburgh and the Tendring Peninsula have larger, more reliable sample sizes. In these two areas the results have demonstrated the possibility of significantly refining the search for Palaeolithic deposits on the seabed and, whilst these will be discussed as case studies in Chapter Five, it is important to note the implications that this has for the overall results.

What these areas demonstrate is that these methods not only have the ability to refine this dataset into broad assemblages characterising broad areas of seabed, but that this can be pushed even further to singling out specific locations. Furthermore, it shows the range of possible scales, and therefore questions, which can be addressed through these datasets. The potential for higher-resolution information tackles local insights into hominin behaviour or ecologies of submerged landscapes, with broader evidence addressing longer-term patterning of environmental and archaeological change.

4.7.2 What do their distribution and patterning tell us about the offshore resource?

The broader patterns in the data suggest that the material being dredged from the Dogger Bank area is similar in character to that being dredged off the southern fishing grounds and that both are dominated by post-Elsterian species. This contrasts with Happisburgh, Cromer and West Runton, areas closer to the coast, which show pre-Elsterian assemblages. Southwold and the Tendring Peninsula to the south, are, by contrast, dominated by post-Elsterian species (although Southwold has less of a distinction between the two, and a smaller sample size [Figure 4.10]). Do these patterns imply total reworking of the fauna on the seabed, or can we infer that this material derives from distinct Pleistocene deposits?

To address this question it is important to understand the processes that will have affected deposits from these areas, and where once-terrestrial areas would have been. During the early Middle Pleistocene, the North Sea formed a shallow marine embayment with coastlines (during high stands) seaward of where they are today along the East Anglian coast, and forming a coastal plain at approximately 52°N (Figure 4.26). Although these areas were not directly glaciated throughout this time, during cold, low-stand periods (broadly speaking MIS 18, 16 and 14) the area to the north of the highstand coastline formed part of the Rhine-Thames-Meuse delta system (Hijma et al 2012).

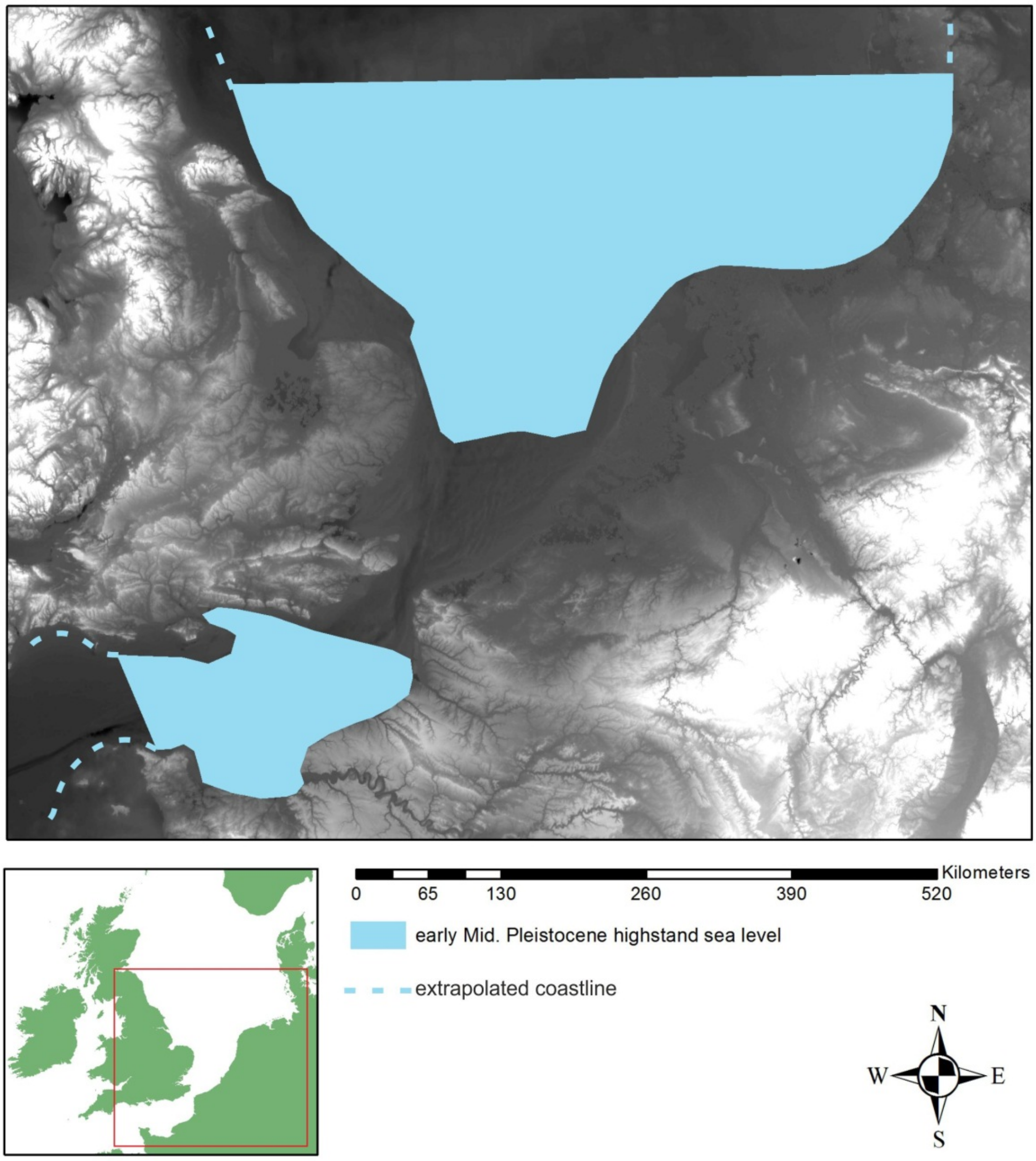


Figure 4.27 Pre-Elsterian, early Middle Pleistocene coastline showing with dry land to the south. (after Hijma *et al.* 2012).

After the Elsterian glaciation and at least the initial breaching of the higher ground where the Dover Straits exist today, the southern North Sea was variably submerged at each high stand. Higher sea levels would have created an island out of modern-day Britain or at least created a coastline that is unfamiliar in modern standards (Gibbard 1995, 2007; Gupta *et al.* 2007; Hijma et al 2012; Toucanne *et al.* 2009a; Busschers *et al.* 2008). During low stands, however, Britain became a peninsula of North West Europe; faunal and floral exchange was once again possible and the southern North Sea would have been occupied by varied and dynamic communities. This does present an oversimplified picture, but essentially this cyclical pattern of sea level change occurred in complex patterns throughout the Pleistocene.

Despite these issues, what this means for the patterning of the specimens is that deposits of post-Elsterian date which yield terrestrial remains are more likely to reflect a cold-stage fauna than an interglacial one. This pattern is certainly seen within the species recovered for this research, with the collection clearly dominated by 'mammoth steppe' fauna (Figure 4.3). Areas that have yielded relatively high numbers of pre-Elsterian or interglacial species have all been along the coastal strip, reasonably within areas that, because of differences in topography and bathymetry, could have been terrestrial even during high sea level stands (Figure 2.3).

The fact that we see any patterning to the submerged Pleistocene resource is extremely encouraging, and that the patterns are those that we would expect to see has even more positive implications for the integrity of the record. A more in-depth discussion of these patterns, as well as how they relate to the bigger Palaeolithic questions will be discussed in Chapter Six, after the case studies of the smaller-scale, high-resolution locations have been presented.

4.8 Conclusions

The results of this analysis demonstrate the amount of latent information contained within the prolific faunal resource from the submerged zone. Despite being overlooked for over a century, the combination of a historiography of the trawling industry with information about collectors can re-imbue these finds with varied levels of context.

Although predominantly at a broad scale the observed patterning is arguably significant and is likely to reflect the more fragmented picture of pre-Elsterian deposits relative to those from the more recent post-Elsterian: a fragmentary landscape, primarily dominated (at least superficially) by later Pleistocene material. Fragmentary patches of earlier material are likely to exist throughout, but are prevalent in distinct areas of good preservation. The fact that areas of higher resolution with coherent results exist provides an encouraging and exciting route to more in-depth analysis and, potentially, to ways of further interrogating the lower-resolution data from further offshore. Chapter Five will present these case studies and discuss the potential for tangible engagement with these deposits.

These results therefore present a substantial increase in what we know about the submerged Palaeolithic record and what it can tell us about contemporary deposits. Moving the situation from one dominated by Quaternary deposit models, it has brought the artefactual record into focus and provides foundations from which we can begin to understand and interrogate the submerged zone.

Chapter 5: Investigating higher resolution patterns

The case studies of the Oyster Bed and the Tendring Peninsula

The patterns identified throughout the course of this research have significant implications for the potential of intact Pleistocene deposits to be discovered on the seabed. Chapter Three saw the teasing-out of small-scale historic trawling practices (Section 3.2.2) which were analysed as distinct locations in Chapter Four (Section 4.4.2.1). The specific areas of the Happisburgh Oyster Bed and the seabed off the Tendring Peninsula (i.e. off Clacton, see Figure 5.1), both with larger sample sizes, move from the broad-scale patterns to increasingly refined locations. This chapter will focus on the specimens recovered from these areas, looking also at how these fit into the wider picture. The case study of the Tendring Peninsula, with fossil specimens recovered over the past thirty years, will be a specific focus and will demonstrate the ability to recognise and target defined fossil-bearing locations on the seabed.

Groupings within the collections will be analysed and discussed with regards to species associations, skipper-identified locations and the incorporation of new geophysical data collected for this research. The potential for this to develop the way we work with submerged data, moving towards a more focused approach, will be explored and the methods for detecting human agency within such collections discussed.

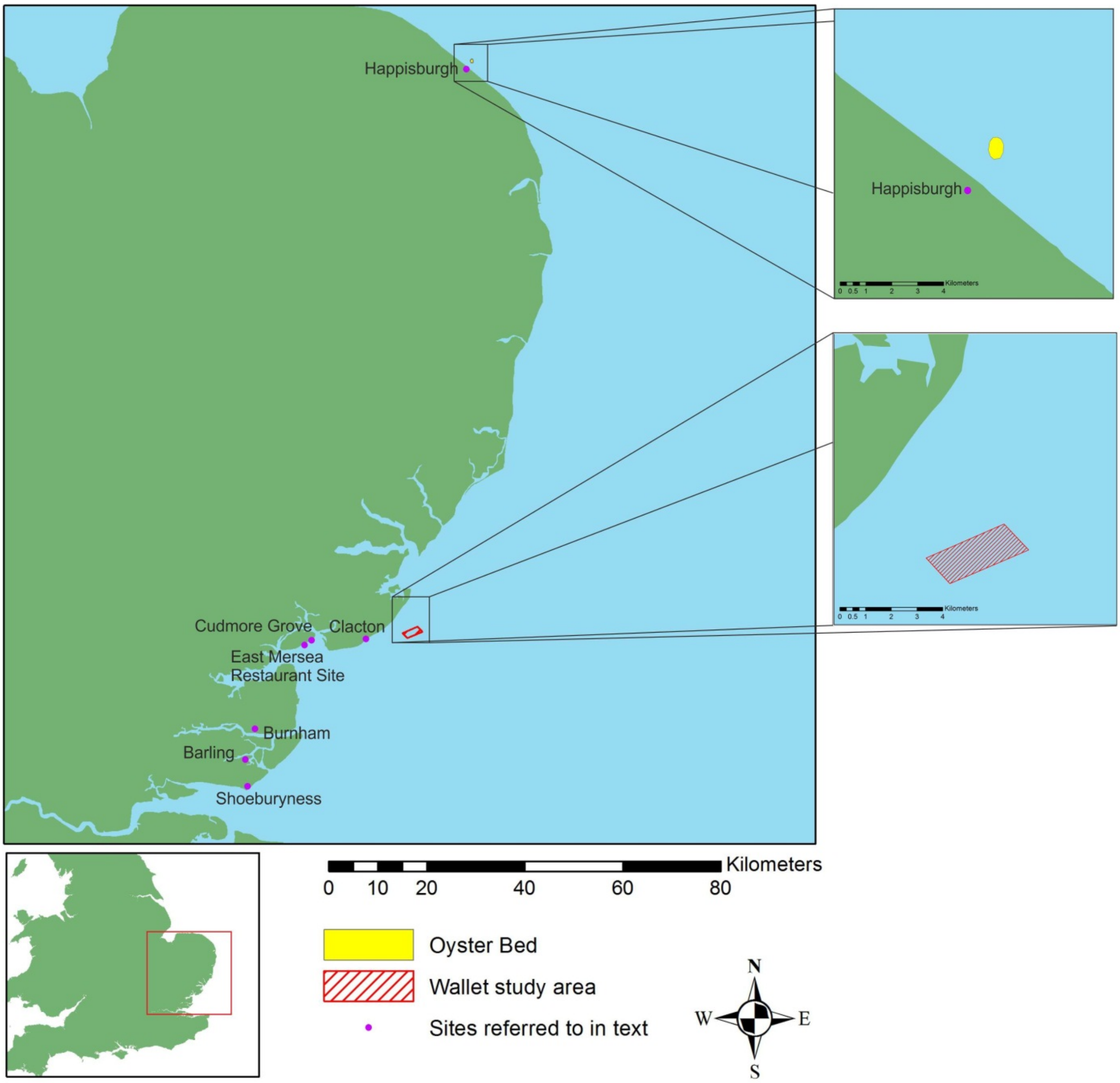


Figure 5.1 Sites discussed in the text, showing the interpreted location of the Oyster Bed off Happisburgh, and the Wallet Study Area off Clacton.

5.1 Case Study 1: The Happisburgh Oyster Bed

Chapter Four identified a broad trend among the coastal locations of East Anglia (Figure 4.8, 4.11), with higher proportions of pre-Elsterian species in the north, moving to post-Elsterianin the south. The area near Happisburgh was one of the best represented locations with 49 specimens (42 that were identified to species), predominantly derived from one collector: Reverend James Layton (Figure 5.2;

Text Box 5). This section will begin by characterising the geological setting of the area onshore and offshore Happisburgh, before looking in more detail at the species recovered from the Oyster Bed and its potential location.

5.1.1 Archaeological and Geological background

The area around Happisburgh is dominated by Pleistocene deposits of the CFbF, overlain by cliffs made up from Elsterian till (Rose *et al.* 1999; 2000; 2008; Preece and Parfitt 2001; 2012). As shown in Text Box 4 the deposits of the CFbF are extensive but by no means continuous, forming from c.1.8Ma until the Elsterian glaciation, with significant hiatuses throughout. Recently, deposits at the site of Happisburgh 3 have been excavated (Text Box 2; Parfitt *et al.* 2010), identifying Early Pleistocene deposits with evidence of hominin occupation in the upper estuarine reaches of a large river system (Parfitt *et al.* 2010; Ashton *et al.* 2014). Coastlines were clearly further eastwards than today, implying the potential for the existence of fragments of these deposits in the currently submerged zone.

The foreshore deposits shown in Figure 4.13 demonstrate the lateral extension of these deposits into the inter-tidal zone and have yielded archaeology from younger CFbF dates (e.g. Happisburgh 1 [MIS 13]: Ashton *et al.* 2008a). In addition, large quantities of pre-Elsterian remains have been found washed up onto the beaches in this area, as well as within these deposits. Understanding the deposits offshore is therefore a priority for placing the finds into some kind of context, as well as linking the onshore and offshore zones.

Recent geophysical mapping in the offshore vicinity (Limpenny *et al.* 2011), combined with a coarser-grained record (Cameron *et al.* 1992) shows the existence of the Yarmouth Roads Formation (Figure 4.12), the offshore correlative of the CFbF. These deposit models, however, are based on widely-spaced geophysical lines ground-truthed by occasional cores, meaning that extrapolation is necessary and localised deposits may be missed. Higher resolution swath bathymetry (Environment Agency, Norfolk County Council) in conjunction with onshore ERT (Electrical Resistivity Tomography) and EM (Electromagnetic methods) shows what appears to be a series of channels running into the offshore zone which are thought to tie-in with early Middle Pleistocene deposits extant within the cliff section (ongoing work being undertaken by University of Wales Trinity Saint David, University of St Andrews, Queen Mary University, University of Southampton, British Museum and Natural History Museum). At present, there are two scales being worked at for the cliff deposits: the larger scale (with 5m spacings) which shows large channel systems down to a depth of around 40m, and a smaller scale which, with 1m spacings, shows smaller channels nested inside the larger (Bates pers. comm.). Sub-bottom seismic data was collected by Wessex Archaeology in 2006, however, which came to within 400m of the shoreline and comprised four parallel lines immediately offshore from Happisburgh. This data, which did not include any corresponding cores, only recognised deposits of the Westkapelle Formation (approximately corresponding with the upper deposits of the Early Pleistocene Norwich Crag onshore), overlying either late Pliocene Red Crag or Upper Cretaceous chalk (Wessex Archaeology 2008). Given the distance of this survey from the shore (necessary due to the presence of groynes), and the difference in height (OD) of the seabed at this point (between 11.1m and 15.9m) compared with that of the foreshore deposits (~0m), it is possible that younger deposits are extant in the intervening zone.

The discovery of the archaeological site of Happisburgh 1 indicates the existence of younger early Middle Pleistocene deposits in the vicinity (Ashton *et al.* 2008a). Attributed on largely biostratigraphical grounds to MIS 13 (due to the presence of the vole *Arvicola cantiana* as well as a similar coleopteran assemblage to High Lodge and Waverley Wood shown to have formed within late aggradations of the Bytham river [Ashton *et al.* 1992; ibid.]) this site highlights the lack of vertical separation of deposits along this stretch of the coastline, demonstrating how sites separated by several hundred thousand years can exist at much the same elevation (Rose *et al*. 2001). Moreover, it draws attention to the difficulties involved with having chronological control over these deposits, compounded by the lack of reliable dating techniques (cf. Penkman *et al.* 2011).

Deposits in the vicinity of the Oyster Bed therefore appear to be a mixture of Yarmouth Roads (CFbF) and Westkapelle (youngest Norwich Crag) Formations.

5.1.2 Species characterisation

The species from the area of Happisburgh were predominantly recovered by Reverend James Layton (Figure 5.2) who was extremely interested in natural history (Text Box 5). He paid particular attention to the specimens that were dredged from the location of the 'Oyster Bed' by oyster dredgers during the 1820s and published a letter on these finds in the 1827 volume of Edinburgh Journal of Science (1827, 199). His collection was eventually deposited with the Natural History Museum, London.

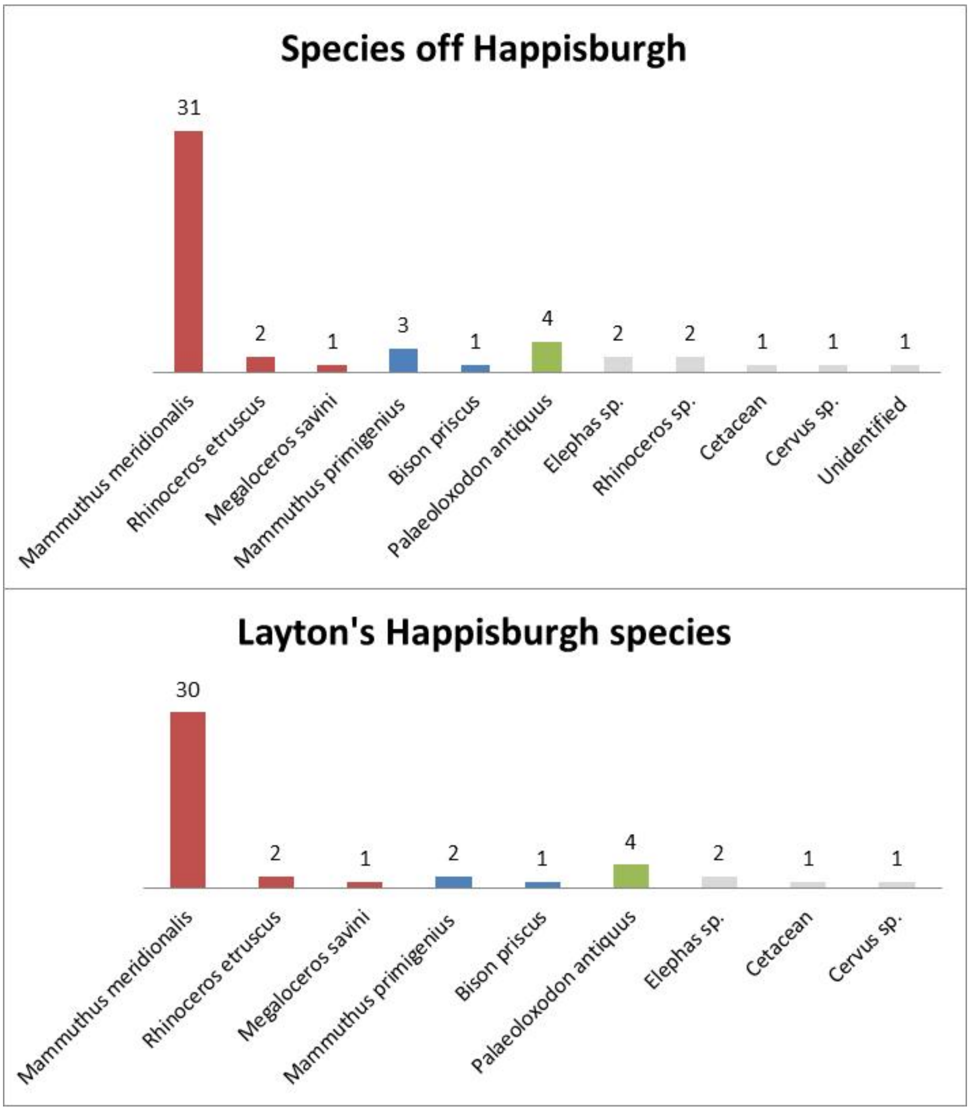


Figure 5.2 Species off Happisburgh, showing those collected solely by Layton. As throughout Chapter Four, red shows pre-Elsterian, Blue shows post-Elsterian, Green indicates species which span these periods and grey are indeterminate to species level.

The wider collection from Happisburgh also includes five specimens recovered from other collectors; their inclusion in the assemblage does not change the patterning observed (Figure 5.2). Given Layton's explicit interest in the Oyster Bed, however, this study will concentrate solely on his specimens. Analysing this collection shows a striking dominance (83% [n=33] out of those identified to species [n=40]) of pre-Elsterian species (Figure 5.2).

Figure 5.3 *Palaeoloxodon antiquus* from Layton's Oyster Bed collection

The addition of the species *Palaeoloxodon antiquus* (straight tusked elephant, Figure 5.3), the only species within this assemblage that spans the early Middle – Late Pleistocene, seen at sites such as Pakefield, could reasonably be added to this group, increases the number to 95% (n=37). But how likely are these associations? Previous assemblages attributed to this pre-Elsterian period have included quantities of *Mammuthus meridionalis* (Southern mammoth) in association with typical pre-Elsterian species such as *Megaloceros dawkinski* and *Cervus latifrons* (pre-Elsterian giant deer species). This works well due to the extension of *Mammuthus meridionalis* into the later part of the early Middle Pleistocene

(~0.6Ma, MIS 15/14). However, the association of this species with *Stephanorhinus etruscus* (Early Pleistocene rhinoceros [Breda *et al.* 2010]) implies that it is more likely that the Oyster Bed, where they're deriving from, is an Early Pleistocene deposit. The single presence of *Megaloceros savini* (pre-Elsterian giant deer) possibly supports this, with its appearance in Europe during the Early Pleistocene (~1.3-0.5Ma [van der Made and Tong 2008; Kahlke *et al.* 2011]), although this species does not appear to have been found in Britain earlier than at Pakefield (i.e. MIS 17/19 [Parfitt *et al.* 2005; Preece and Parfitt 2012]). It is therefore most probable that the Oyster Bed, at least in part, is an Early Pleistocene deposit, in which case the *Palaeoloxodon antiquus* (straight tusked elephant) specimens are likely to be deriving from a deposit of different age. Given the time transgressive nature of the CFbF deposits in this area, the existence of early Middle Pleistocene deposits in the immediate offshore area is likely and is supported by geophysical mapping (Figure 4.12; Cameron *et al.* 1992; Limpenny *et al.* 2011).

5.1.2.1 Locating the collection

What is most exciting about these finds is that there is the potential for locating them on the seabed. The oyster bed was an ephemeral occurrence and one which (apparently) was not formally mapped, making its location somewhat ambiguous. Despite this, with the finding of archived maps at the offices of Imray, Laurie, Norie and Wilson, inspection of a chart from 1826 was possible. This chart shows a few areas that could be likely candidates and Figure 5.4 shows a modern (1964) fishing chart with an insert of the area concerned. The insert shows two obstruction/ridge areas, the smaller of which is approximately ¾ mile from the shore opposite Happisburgh, which is the approximate location described by Reid in his 1890 publication (1890, 174). The correlation of this seabed feature with the original description supports the interpretation that this could be the location of the Oyster Bed and therefore seems like a logical place to begin ground-truthing for deposits and faunal remains.

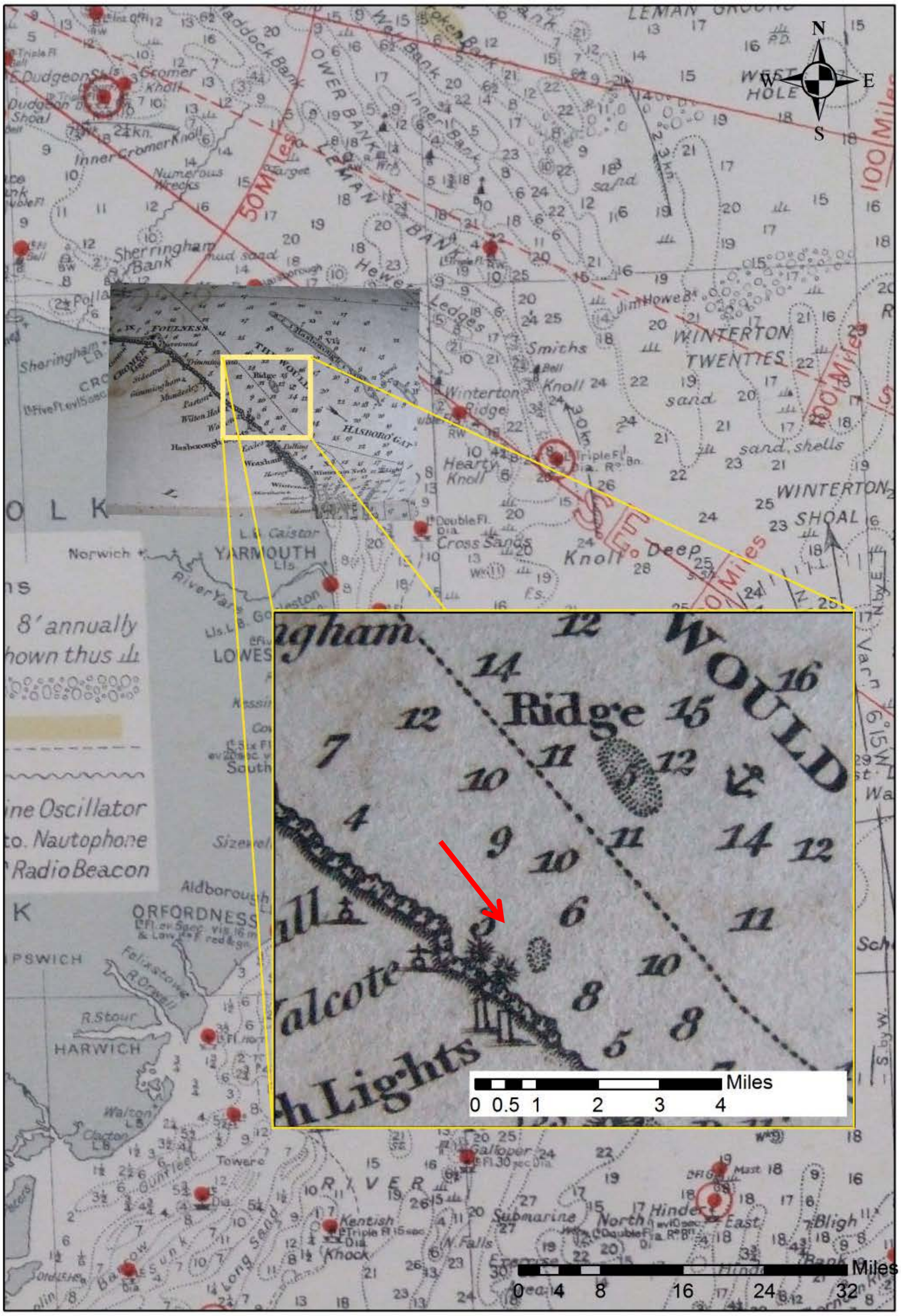


Figure 5.4 Imray, Laurie, Norie & Wilson fishing chart from 1964 with expanded box of an 1826 chart showing the presence of a ridge/area of seabed obstruction in the location of the described Oyster Beds.

In the vicinity of Happisburgh there are some other interesting correlations, specifically the specimens from the Sea Palling area, immediately to the south. These have been recovered after being washed onto a specific section of the beach and fall into two pre-Elsterian assemblage types: a later early Middle Pleistocene assemblage and an Early Pleistocene assemblage (Chapter Four, Section 4.2.1.1 [Parfitt pers. comm.]). This is especially significant given the known hominin occupation of these landscapes in the early Middle Pleistocene (Ashton *et al.* 2008a).

An English Heritage funded project is currently underway investigating these offshore deposits and how they relate to those of the onshore CFbF in this area. This project will hopefully be shedding light on the correlation of these spatially restricted assemblages, linking them in with fragments of Early to early Middle Pleistocene deposits offshore. The differences between sediment transport regimes in the near-shore areas versus those further offshore may also shed light on the patterning and movement of specimens and improve our ability to provenance material.

5.2 Case Study 2: The Tendring Peninsula

In a similar way to Happisburgh, the majority of the specimens recovered from the seabed off the Tendring Peninsula were recovered by one man - Mr Les Brand - over the past thirty years. In addition, the historic collections of bones from this location also appear to have been derived from the seabed within a few kilometres of the coast. This section will provide a geological and archaeological background to the area in question before looking in more detail at the collection itself.

5.2.1 Archaeological and geographical background

The Tendring Peninsula and surrounding coastal areas of South-East Essex are dominated by various spreads of low-lying fluvial terrace gravels cut into the underlying London Clay, relating to river systems which both pre and post-date the Elsterian Glaciation (Bridgland *et al.* 1999; Roe *et al.* 2009; Roe and Preece 2011;

Roe *et al*. 2011). The northern extent of the area, near Little Oakley, contains deposits which document the position of the Thames whilst it was depositing its pre-Elsterian Kesgrave Sands and Gravels: sites such as Little Oakley (Preece *et al.* 1990), Wivenhoe and Ardleigh (Bridgland 1988; Rose *et al.* 1999; Rose *et al.* 2010). Despite their extensive nature, these sands and gravels are surprisingly lacking in archaeology, with only a few potential find spots (Hosfield 2011 [as well as the Happisburgh 3, which has been assigned as part of a converged Thames/Bytham system flowing out of north Norfolk in the Early Pleistocene (Parfitt *et al.* 2010)]).

During the Elsterian stage, glacial ice diverted the Thames south to its current course (Bridgland 1988; 1994). The deposits to the south of the Tendring Peninsula are representative of these late Middle Pleistocene fluvial landscapes, differentiated from the earlier Medway gravels by their distinctively post-Elsterian clast composition (Bridgland 1988). Several sites of archaeological importance have been discovered associated with these myriad channel systems and a complex set of biostratigraphic and amionostratigraphic criteria, as well as river terrace positions, have been used to assign them to specific interglacial periods (Bridgland 1994; Roe *et al.* 2009; Roe and Preece 2011).

The internationally important site of Clacton, type-site of the Clactonian industry, is part of this fluvial sequence and, forming part of the first interglacial, post-diversion drainage route taken by the Thames river system, has been unequivocally dated to the first post-Elsterian interglacial: the Holstenian (MIS 11) (Bridgland 1988; Bridgland *et al.* 1999). The channel-fill sequence which encompasses these richly fossiliferous deposits is the downstream equivalent of the Swanscombe sequence in Kent, supported by biostratigraphy, aminostratigraphy and terrace stratigraphy (McNabb 2007). The amount of evidence from these sites (in addition to archaeological sites in other locations such as Hoxne, and purely environmental sites such as Marks Tey) provides a rich database of information for at least part of the Holstenian interglacial, meaning that an array of marker species are known: *Dama dama clactoniana*, *Ursus spelaeus*, *Talpa minor* (small mole), *Trogontherium cuvieri* (giant beaver), *Oryctolagus cuniculus* (rabbit) and *Microtus subterraneus* (European pine vole) make up a distinctly Holstenian indicator group (Schreve 2001).

There exist two further interglacial channel deposits in the vicinity which have been extensively studied: Cudmore Grove and the East Mersea Restaurant Site. Contained within estuarine silts and clays in a steep-walled channel-like depression in the London Clay, the Cudmore Grove Channel site has produced several flint flakes (Roe and Preece 2011). Accumulating throughout much of an interglacial sequence, this channel sequence was deposited in a dynamic and varied coastal environment (*ibid.*). Distinguished biostratigraphically from the Holstenian through the early interglacial presence of the bivalve *Corbicula fluminalis* (which occurs later in all Holstenian assemblages [Meijer and Preece 2000]), this early presence links this site to others which are thought to be attributed to a post-Holstenain stage, MIS 9 (Barling and Hackney Downs [Bridgland *et al.* 2001; Green *et al.* 2006]). Furthermore, the presence of the bear *Ursus arctos* as opposed to the Holstenain-type *Ursus spelaeus*, and recent convincing AAR evidence, place Cudmore Grove within MIS 9 (Roe and Preece 2011).

The East Mersea Restaurant Site is located just 2km along the foreshore from Cudmore Grove and, characterised by a non-marine mollusc assemblage and indicative vertebrates including *Hippopotamus,* can be reliably placed within the Last Interglacial (MIS 5e [Roe and Preece 2011]).

Along with Holocene channels, there are therefore four post-Elsterian interglacials represented in the vicinity of the Tendring Peninsula as well as that of the pre-diversion Thames represented at Little Oakley, tentatively assigned to approximately MIS 15 (Preece *et al.* 1990; Preece and Parfitt 2000; 2012).

The offshore zone has had limited investigation and the offshore picture is generally highly speculative, but several studies have demonstrated the existence of the continuation of these deposits on and under the seabed (eg. Dix and Sturt 2011; DONG Energy 2011). The identification of a pre-Elsterian fluvial system in the north of the Outer Thames Estuary (Dix and Sturt 2011) is likely to be linked to the pre-diversion Thames deposits flowing across the Tendring Peninsula (Preece *et al.* 1990; *ibid.*) and, although initially incised in the early Middle Pleistocene, has yielded deposits from a range of Early to Late Pleistocene and Holocene dates (Dix and Sturt 2011), indicating cyclical re-activation of this system. The potential therefore exists for a range of Pleistocene – Holocene deposits on the seabed in this area.

The continuation of the Clacton Channel has been inferred offshore by Bridgland and D'Olier (1995). More recently, geophysical and geotechnical work in the area has picked up a Pleistocene palaeochannel system immediately offshore Clacton (DONG Energy 2011; Heamagi pers. comm.), although these deposits have yet to be dated. The same work has also identified Holocene Channels cut into these Pleistocene deposits. Although in approximately the same location as the proposed Clacton Channel continuation, evidence from the offshore channel deposits appears to correlate with either the Cudmore Grove channel system (MIS 9) or, potentially, the following interglacial, MIS 7 (Figure 5.7; Dong Energy 2011, 154).

In terms of a later Pleistocene signal Bridgland and D'Olier (1995) have presented offshore maps of Late Pleistocene deposits of the Thames – Medway system. However, due to a relative dearth of deposits, much information about the evolution and direction of these systems is unknown (*ibid.*). It is thought that during the Late Pleistocene this area would have been dry land at the head of these Thames-Medway systems (Bridgland 1995). There is therefore potential for Late Pleistocene terrestrial deposits in the vicinity, although these have yet to be identified.

In summary, deposits from a range of ages exist in this offshore area documenting the evolution of a dynamic sea/landscape throughout the Pleistocene and into the early Holocene. Archaeologically speaking, the coastal areas are dominated by late Middle Pleistocene sites although these are still few. The small number of MIS 3 sites, when much of this area would have been dry land, is surprising, especially given the clear presence of Neanderthals on the other side of what is now the southern North Sea basin (Hublin *et al.* 2009; Semal *et al.* 2009). Perhaps the low-stand Channel River, although with productive tributaries and lower energy areas, provided a significant barrier to cross.

Faunal specimens recovered from this area will need to fit into distinctive biostratigraphical assemblages if they are to provide clear signals for the age of their parent deposit, but the addition of new geophysical as well as future geotechnical and ground-truthed data should help to clarify this position.

5.2.2 Locating the collection

The specimens recovered by Mr Brand can be well refined on the basis of his localised trawling patterns, meaning that we can begin to link collections back to areas of seabed. The significance of this lies in the leap in approaches to the submerged zone that this provides: being able to engage with specific Pleistocene seabed deposits which are known to be yielding Pleistocene fauna. This section will discuss the ways in which these locations have been refined, present new geophysical data collected for this research and link this back in with current geological knowledge to provide a clearer picture of the context for these specimens.

5.2.2.1 Understanding trawling patterns

Having trawled the seabed off Clacton for several decades, Mr Brand had developed well refined trawling patterns all within close proximity to the coastline. Describing the process as like "*a game of cat and mouse*", these trawling grounds depend, unsurprisingly, on the areas of seabed inhabited by fish at any particular time. This knowledge is not only built-up over many years but also extremely seasonal, with the gutting of fish and observing the types of foods in their stomachs guiding the trawlers to different grounds at different times of year.

In terms of seabed morphologies, trawling will take place across all areas: flat muddy areas, sand banks, gravels, the only area that is avoided would be areas with large boulders or known obstructions (such as wrecks or unexploded ordnance, of which there are many in the area).

Mr Brand trawled with a twin-rigged Otter Trawl, which used four inch rubber weights tied together by a rope of chain to drag across the seabed. Given the earlier assertion that otter trawls may be less likely to recover fossil material (Section

3.2.1.5), this large faunal collection is evidence to the contrary (or, potentially, indicates an abundance of material in this location). The implications of this for recovery patterning in the historic record will be discussed in Chapter Six.

5.2.2.2 Refined locations

Through working with the Colchester Museums Service, it was possible to meet Mr Brand and discuss the location and recovery of his specimens. Although there are several areas where bones have been recovered, these are all fairly distinct from one another. For example, one area was well known to local skippers as the location of a large, probably relatively modern, whale carcass yielding bright white bones (Figure 5.5). He also identified two crucial areas: one that has yielded approximately 80% of his specimens, an area 1km x 3km in the Wallet, near Gunfleet Sands as well as another area which corresponds to a core through submerged palaeochannel deposits identified as Last Interglacial in date (OSL dated to c.116ka [Dix and Sturt 2011]).

Figure 5.5 shows a chart documenting the areas of seabed that have yielded bones, and highlighting the area of The Wallet, where the vast majority of bone material has come from.

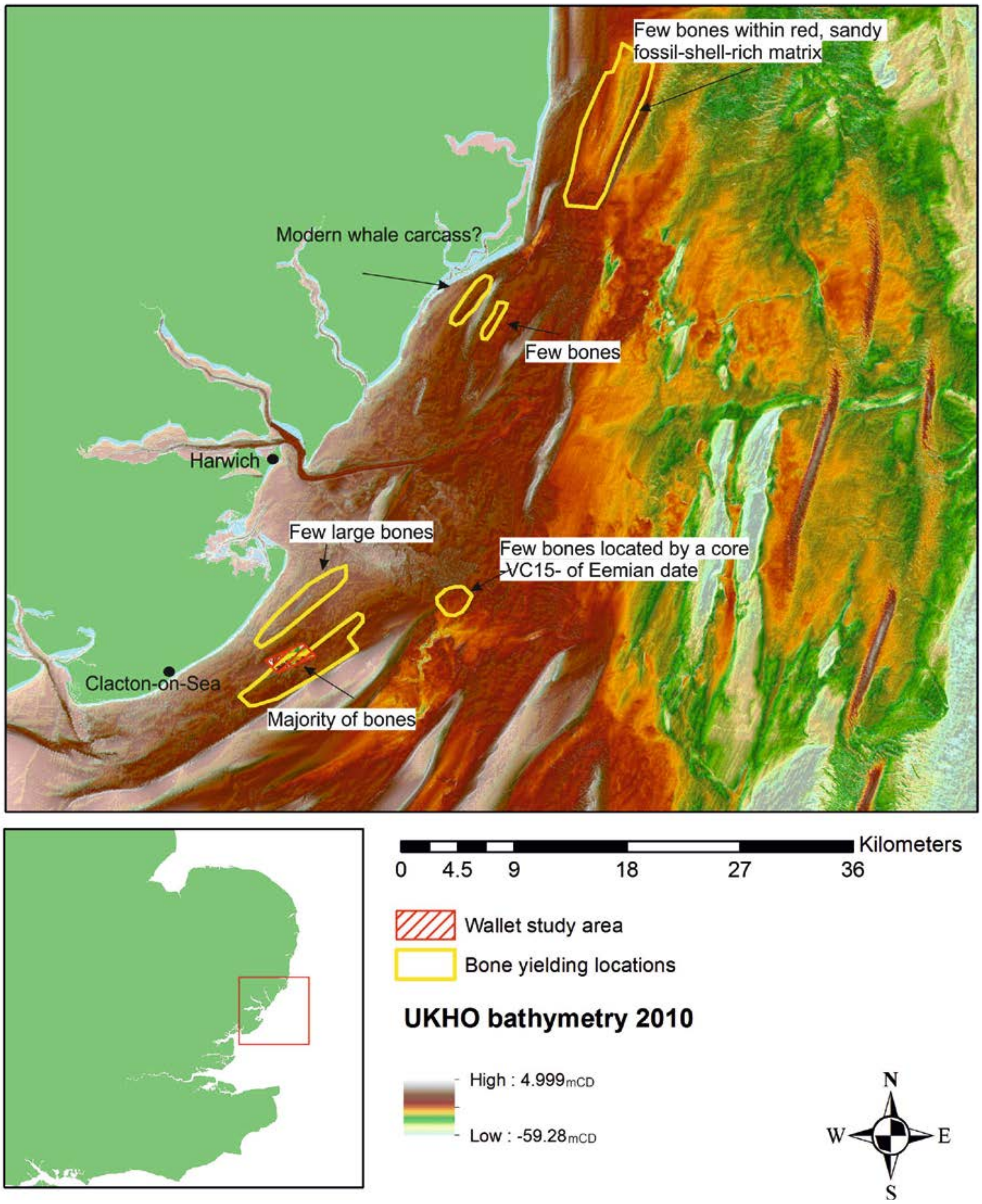


Figure 5.5 showing areas that have yielded bones (Brand collection only). (Data source: UKHO bathymetry)

The Wallet is a seabed feature situated approximately 4km off the coast of Clacton on Sea running parallel with the coastline in this area (Figure 5.5). From Admiralty Charts the seabed around the Wallet is defined as coarse sands with black shells and rocks, to mud, coarse sands and black shells. BGS seabed sediment maps have similarly shown the area to be dominated by muddy, sandy, gravel (Figure 5.6), but as illustrated, this mapping is on quite a crude scale and cannot provide a great deal of detail about the nature of the deposits in question. The presence of black shell material, however, as noted on the chart, has also been found by Mr Brand occurring in areas where he has recovered Pleistocene bone material and described as 'old fused-together oyster shells'; a potentially significant correlation.

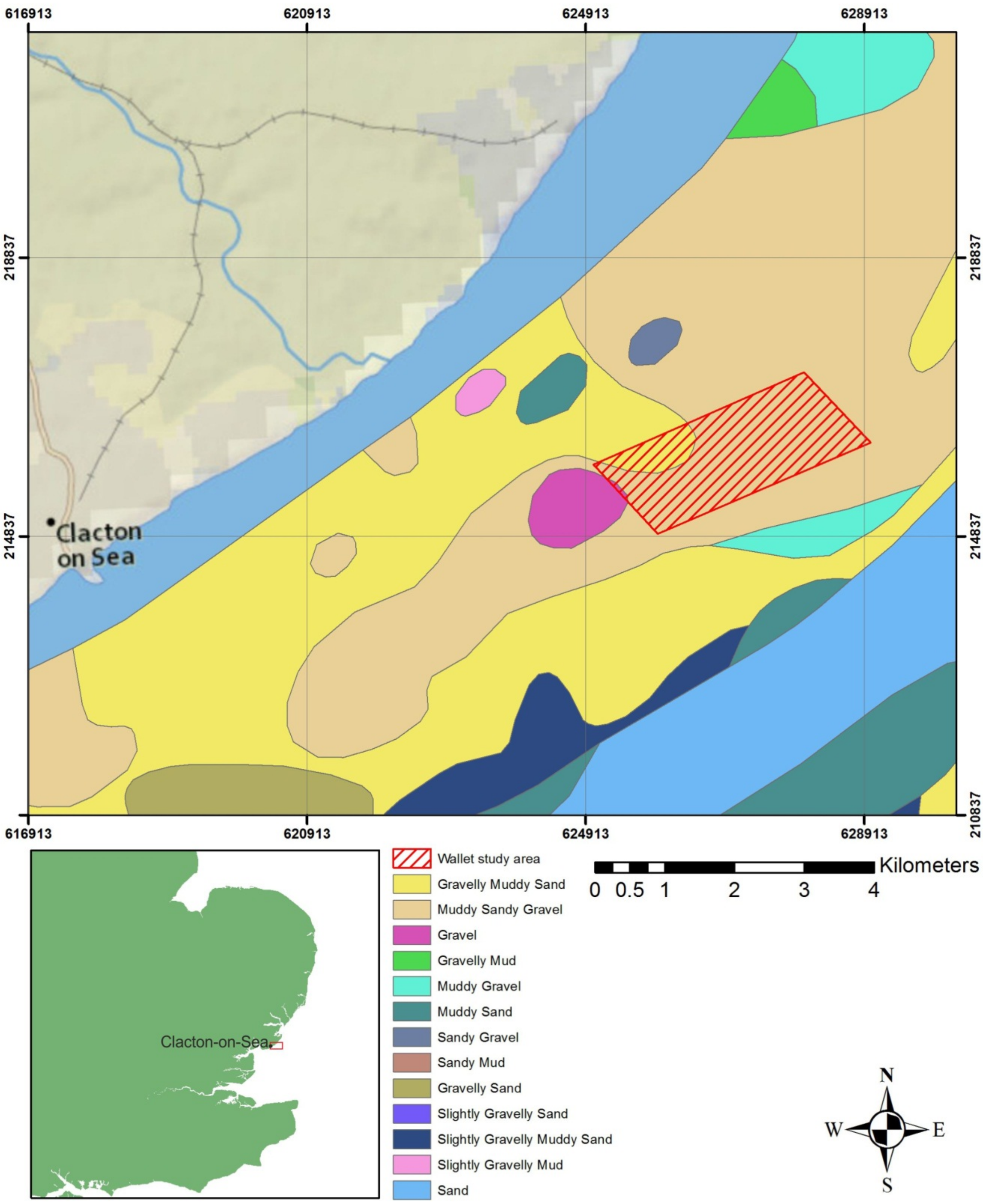


Figure 5.6 British Geological Survey seabed sediments in and around the Wallet study area, shown in red hatches. (www.bgs.ac.uk)

Despite being several kilometres in total length, the area defined as producing material from the Wallet is a fraction of this and the study area is located at the north-eastern extent (Figure 5.5-5.9). At approximately 1km by 3km, this defines the main study area for this work. Despite several other areas of seabed within 40 kilometres also yielding faunal material, the Wallet has not only produced the most, but been the most consistent in terms of recovery. Since specific faunal remains cannot be attributed to specific locations, however, the faunal material is described as a whole (Section 5.2.3).

Having these locations, although not precise GPS coordinates, provides a significant advantage over the historic collections as they reduce the area over which the specimens may yield from. A 1kmx3km square may not be insignificant in size, but it is far reduced from the Dogger Banks 260km x 97km (Stride 1959), for example. Working with the combination of this more detailed information and the faunal identifications for this area means that we can begin to engage with these areas of seabed in significantly more detail.

In October 2013, swath bathymetry data acquisition by the Environment Agency was commissioned by Southampton to specifically cover the 1kmx3km study area within the Wallet. This was done using state of the art attitude and position measuring system and a multibeam bathymetry sonar system. The vessel was positioned using an Applanix POSMV-320 (S/N 3878) system and post-processed using an Applanix Singlebase™ RTK solution. The bathymetry was collected using a Reson 7101 multibeam sonar system (S/N 1810014). This data collection allows the majority of the finds to be slotted into a constrained and interpreted context.

What does this data show?

Data from the surrounding area, as discussed in Section 5.2.1, show a multitude of deposits from various stages of the Pleistocene, which potentially correlate with the largely post-diversion southward-migrating Thames sequences mapped in the onshore zone (Figure 5.7). Whilst these are based on field observations their extension into the offshore zone is speculative, with the only known and mapped deposits relating to recent windfarm developments (e.g. DONG Energy). Interpretation about seabed deposits, however, can be made from bathymetric data.

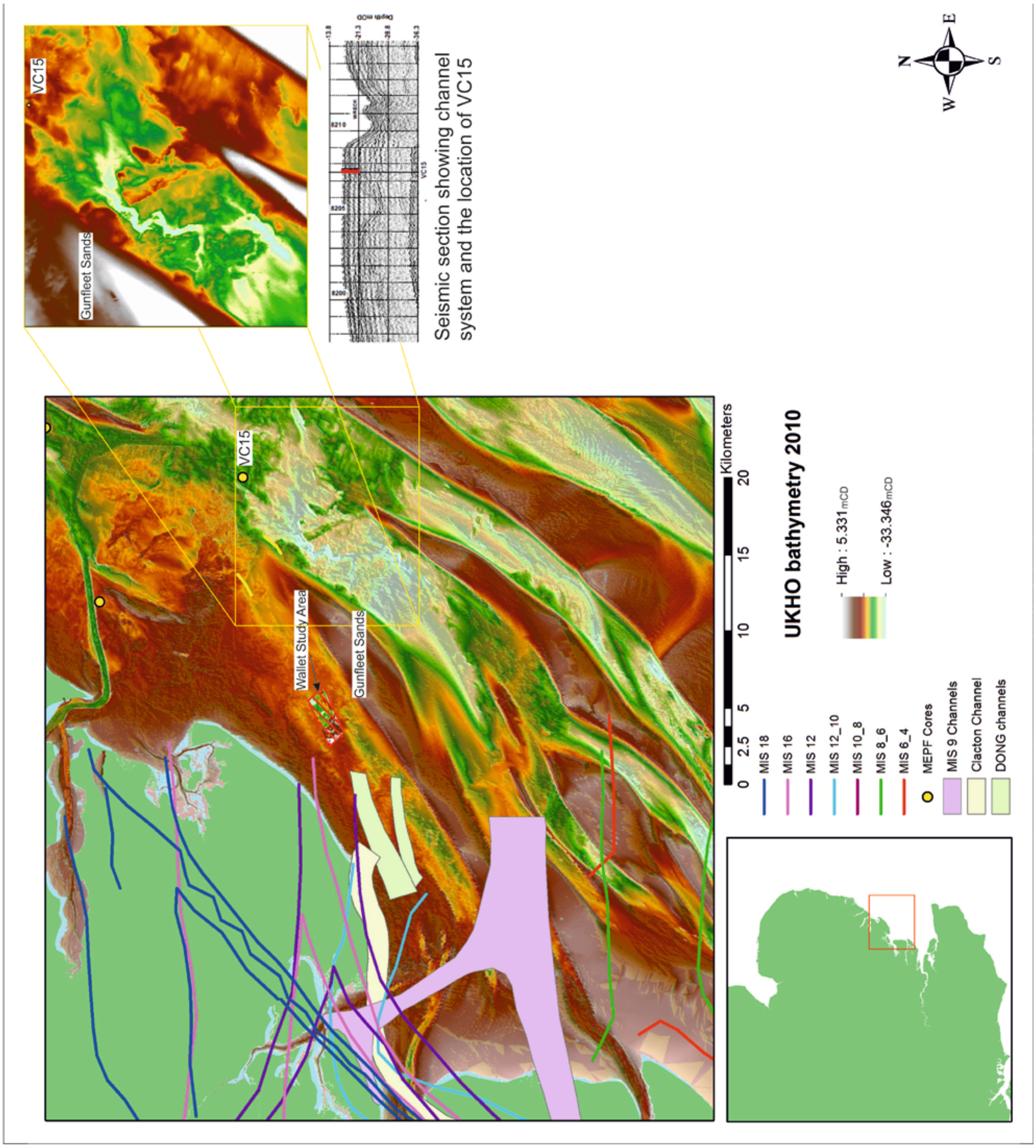


Figure 5.7 Showing the location of the Wallet Study are in its broader context: the mapped onshore channels (after Bridgland *et al.*), offshore DONG Energy (2011) channels, the speculative extension of the (MIS 9) Cudmore Grove channel system (Roe and Preece 2011; Roe *et al.* 2009; 2011) and the channel system yielding an MIS 5e date from core VC15, shown in detail in the expanded box with seismic section beneath (Dix and Sturt 2011). (Data source: UKHO bathymetry)

Broader patterns

Although United Kingdom Hydrographic Office (UKHO) swath bathymetry exists for the area, the majority of this was based on 2D data and is at a relatively low resolution. Using this data can reveal topographic highs of, for example, Gunfleet Sands, but on a finer scale it is difficult to discern whether what you can see is a real feature or the product of issues with the data collection or processing. With the addition of higher resolution data sets, such as that collected here (in addition to windfarm data), the existing background UKHO data can be shown to be largely revealing verifiable features rather than data errors.

From the UKHO data, a meandering river system is apparent to the north-east of the study area (Figure 5.7). Seismic sections, analysed through the Outer Thames REC (Dix and Sturt 2011), identified buried aggregate bodies associated with the now buried northern section of this river system and which, through OSL dates and AAR results, have been correlated with regression after the Last Interglacial (Eemian, MIS 5e) high stand (*ibid.*). Combining this with the onshore evidence of terrestrial gravel bodies from MIS 18 – 4, and the coastal deposits from Cudmore Grove and the East Mersea Restaurant Site (Roe *et al.* 2011), there is potential for a range of deposits in the area.

In terms of the morphology of the seabed off Clacton, there are obvious topographic highs (Figure 5.8): the Gunfleet Sands is a large sand bank made up of fine to medium grained sands laid down in a Holocene, post-transgressive environment on what is an almost horizontal bedrock (Dix Pers. comm.). This is unequivocally Holocene in date and we would not expect to find any Pleistocene deposits or specimens associated with it. Similarly, in the first couple of kilometres of the near-shore strip is a wedge-shaped body of Holocene sands which pinch out offshore. Between the two of these features is the area that is most archaeologically interesting: a plateau at approximately -10 to -12mOD which contains the study area within the Wallet.

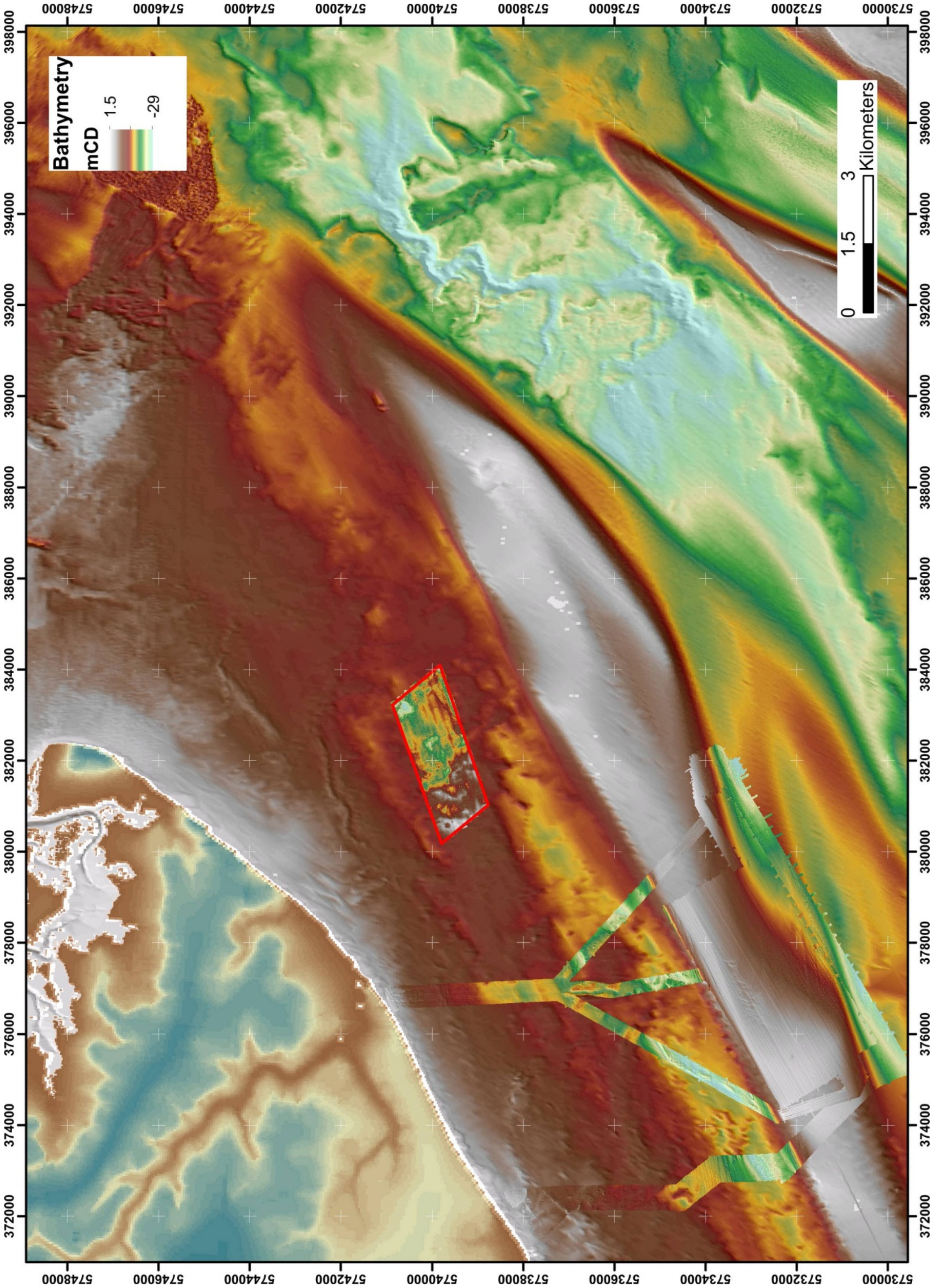


Figure 5.8 Showing the locations and higher resolution datasets of the Wallet study area (outlined in red) as well as the Gunfleet Windfarm and associated cable routes. (Data source: UKHO bathymetry)

Within this plateau zone there are three different sedimentary environments: firstly, zones of clear bedform development suggesting mobile, probably Holocene, sands; secondly, seabed exposures of Tertiary London Clay bedrock, identified by characteristic polygonal faulting associated with the original lithification process of these fine grained sediments; and thirdly, areas which represent competent immobile unconsolidated sediments interpreted as probable earlier Quaternary sediments.

The Wallet data

This 1km x 3km strip has two distinct areas of bedforms: the north-eastern extent displays a few scales of mobile sediments, from very small-scale in the southerly edge of this area to larger towards the northern edge (Figure 5.9). These are likely to be the unconsolidated sandy, modern sediments which have broadly been identified for this area by BGS grab samples (Figure 5.6) and sit at approximately -12mOD. The area to the south-western extent is the most interesting from the perspective of this research. In contrast to the north-easterly extent, this area is characterised by very little evidence of mobile bedforms and is also at a higher elevation at -9.7mOD at the highest, with areas within this of – 11mOD and dropping off to -12mOD where it meets the more mobile section. There are also features which appear to have steep edges associated with them, indicating that they are made up of consolidated material and unlikely to be modern sediments. Furthermore, they do not have the characteristic polygon features associated with the earlier London Clay or the linear furrows associated with the Holocene sediments; instead they are likely to be Quaternary in date and the probable source of the fossil material collected. Finally, it is interesting to note that Mr Brand, whilst refining the entirety of the Wallet to the location of the study area shown, marked this south-western end of the study area as the location most likely to be productive.

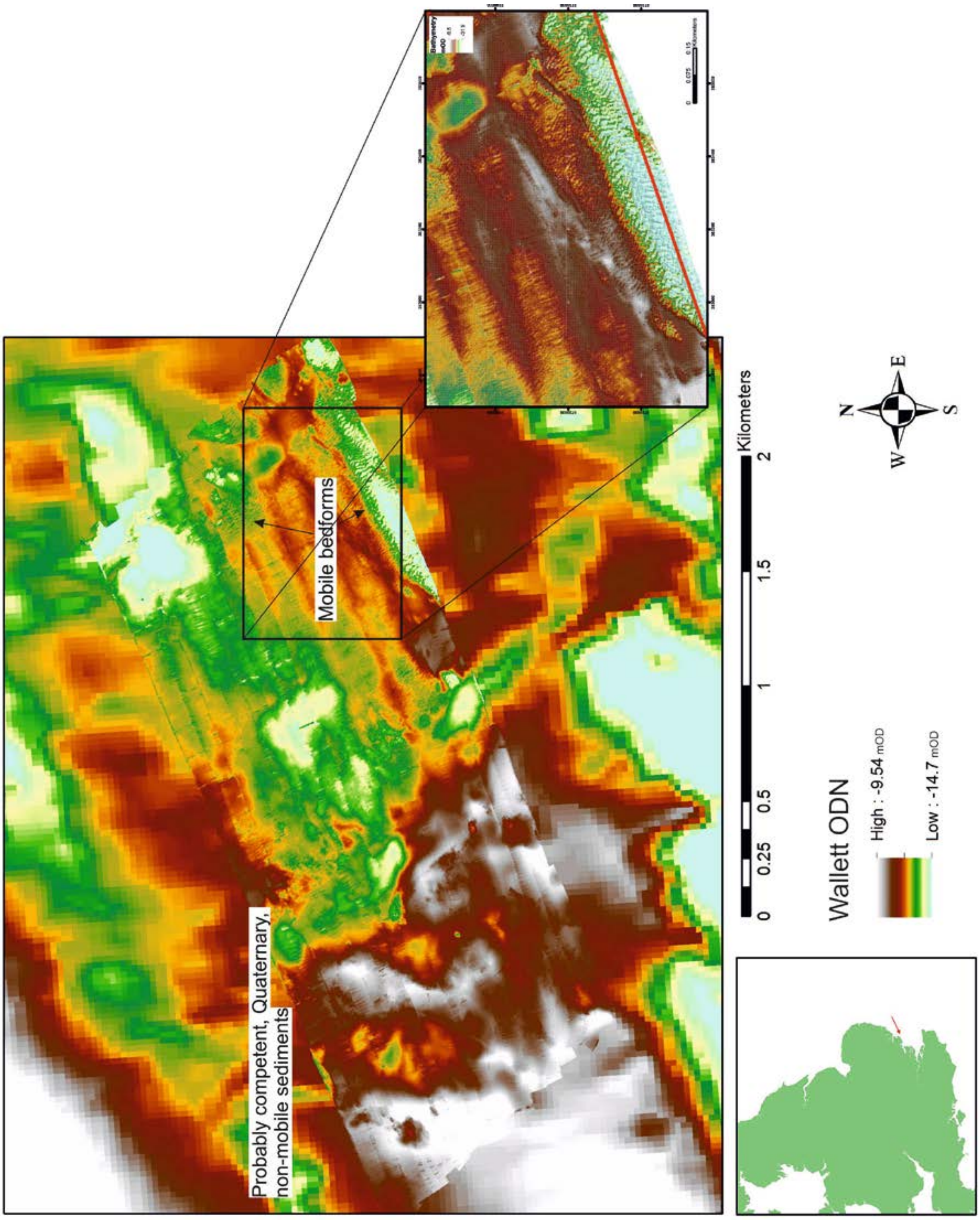


Figure 5.9 Higher resolution swath bathymetry collected for the study area within the Wallet. Showing more competent bedforms in the south-western extent and mobile bedforms towards the lower, north-eastern extent. Value is in metresODN

From the combination of this higher resolution data with the mapping of several channel systems onshore as well as a few offshore (Dix and Sturt 2011; Dong

Energy 2011), the interpretation that the deposits emerging from the Wallet data are associated with the margins of one or more of these systems is gaining ground. This interpretation therefore further reduces the already relatively small size of 1km x 3km down to an area of approximately 1km x 1km for future ground-truthing and diver survey. The following section will now look at the species recovered from this area, before discussing the implications of all of these lines of data for understanding this submerged deposit.

5.2.3 Species Characterisation

Two hundred and thirty nine bones make up the modern collection from the Tendring Peninsula, all recovered by Mr Brand. Throughout his trawling career he has collected many historic and prehistoric finds from the seabed and, although the majority of these relate to modern historical periods, he has built up a large collection of Pleistocene faunal remains which have been donated to Colchester Museums Service.

5.2.3.1 The Brand Collection

The relatively new recovery of these specimens means that their species identification is currently on-going, but there are still interesting patterns that can be investigated in terms of the types and numbers of fauna present. This research has begun to work through the species identifications for the specimens within the collection, identifying them initially to family or genus and later attempting to narrow this further to species level. At present, 88% (n=210) of the specimens can identified to family, 72% (n=173) can be further identified genus and 8% (n=18) to species (Figure 5.10).

A sub-set of the bones – the rhinoceros remains - were concentrated on for further species evaluation as they formed such an unusual abundance within the collection. Due to the number of these specimens (n=81), it was not possible to take them away from Colchester Museums' Service for comparison with reference collections. As such, literature was used to attempt to gain a comparison (primarily: Kahlke and Lacombat 2008; Guerin 2010; van de Made 2010). Measurements of more complete bones were taken, as well as scale photographs, and as a result five specimens were identified more robustly and all were brought within broad size categories.

Below are a series of questions which draw out the importance and the potential of this collection.

- *What is the potential for specifying the age range of the bone-yielding deposits through an in-depth study of the genus and species of the bones themselves?*

With 239 specimens comprising the Brand Collection, it is dominated by the remains of *Elephas sp.* (n=72), closely followed by *Rhinoceros sp.* (n=59) and other undetermined bovids (n=37) (Figure 5.10). The dominance of *Elephas* remains is likely to do with a combination of original presence, taphonomy – and robusticity - and collection bias; significantly these are factors that have not changed since antiquarian times. Unusually, *Mammuthus primigenius* (woolly mammoth) is only securely represented by one specimen, possibly due to the amount of post-cranial remains within the sample that have yet to be analysed (the entire collection of mammoth material is 96% post-cranial [n=72]). Similarly unusually, there are 10 specimens of *Coelodonta antiquitatis* (woolly rhinoceros, e.g. Figure 5.11) so far recognised.

Given the early stages of species identification, patterns in the data are potentially subject to some change. However, broader patterns using genus identification are very worthwhile, especially in terms of abundance of particular fauna such as, in this case, the massive dominance of rhinoceros and elephant remains (Figure 5.10) and how these relate to those specimens identified to species as well as current terrestrial patterns.

To some extent this pattern may be biased by size and robusticity, elephant remains are larger and easier to recover. However, rhinoceros remains are not significantly different to other large bovid remains, such as aurochs or bison, making their abundance in the sample less easy to explain. Historically, another bias was that of the exotic nature of the specimen, but the sample recovered by Mr Brand was not subjected to this as he recovered and kept material regardless of element or species, discarding only the material which was extremely fragmented.

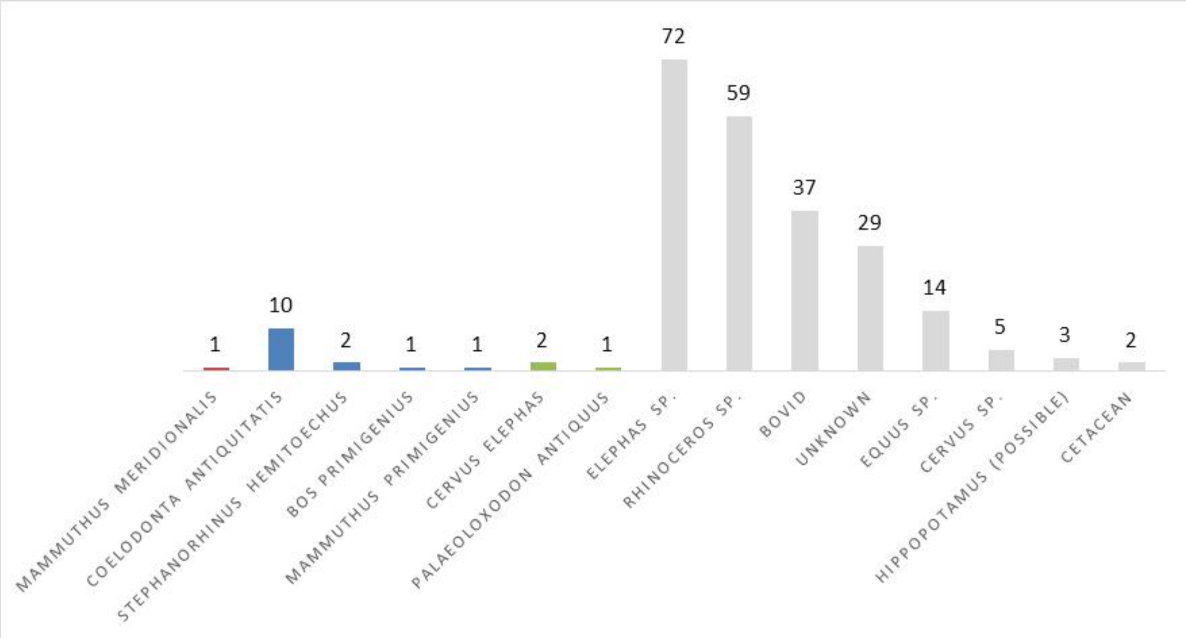


Figure 5.10 Specimens present within the Brand collection

The fact that the collection is dominated almost entirely by terrestrial mammals (there are two cetacean remains) indicates that the bone-yielding deposits are terrestrial and not marine. Aside from the preservational advantages offered by the robusticity of elephant/mammoth remains, the large sample size tells us little about environment or temporal stage at this point. These remains could represent interglacial species, such as *Palaeoloxodon antiquus*, *Mammuthus meridionalis* or *Mammuthus trogontherii*, or the cold-adapted mammoth, *Mammuthus primigenius*. Significantly, an early form of *Mammuthus primigenius*, called the Ilford Mammoth, has been found in abundance at MIS 7 sites in Britain alongside *Coelodonta antiquitatis*, indicating these species' adaptation to open environments, rather than specifically, or exclusively, to temperature (Schreve 2004).

Figure 5.11 *Coelodonta antiquitatis* mandible, off Clacton, Brand Collection

The large numbers of rhinoceros remains could equally represent a range of temporal stages and environments. There is an abundance of pre-Elsterian rhinoceros remains known from the CFbF, but these are so far unrepresented by the trawled material, historic or otherwise.

For the post-Elsterian there are three known species, two of which are seen in the trawled collections as a whole, as well as in this collection: *Coelodonta antiquitatis* and *Stephanorhinus hemitoechus*, with *Stephanorhinus kirchbergensis* as yet unknown from offshore. Although *Stephanorhinus kirchbergensis* (Merk's rhinoceros) and *Stephanorhinus hemitoechus* (narrow nosed rhinoceros) are both interglacial species, their adaptations represent different types of environment, browsing and grazing respectively, and despite having a mutual existence in several interglacials (MIS 11, 9 and 7), *Stephanorhinus kirchbergensis* had disappeared from the British record by MIS 5e, leaving only *Stephanorhinus hemitoechus* present during the Last Interglacial (MIS 5e, c.125-115ka). The other species, *Coelodonta antiquitatis* (woolly rhinoceros), is first seen in late MIS 8 (Schreve *et al.* 2002), but more prevalently in late MIS 7 alongside interglacial species including both *Stephanorhinus kirchbergensis* and *Stephanorhinus* *hemitoechus*, appearing again during MIS 3 (Pine Hole MAZ) associated with a cold-stage fauna (Schreve 2001).

Unidentified bovids are also well represented and, although few are as yet identified to species, these are likely to have a substantial impact on the character of the assemblage. Despite some difficulties in discerning the environments that pre-Elsterian bovids were adapted to (e.g. forests and / or open environments [Sher 1997; Sala 1986]), refining them to specific species will at least aid in determining their temporal nature and, in terms of ecologies, the later species are far more defined (Schreve 2001; 2004).

Hippopotamus, although only identified to genus within this assemblage, is only found in Britain in the pre-Elsterian (*Hippopotamus antiquus*) or the Last Interglacial (*Hippopotamus amphibious*), making it a distinctive marker species for this more recent stage if associated with other Last Interglacial species and an absence of horse (Currant and Jacobi 2001). Although low in numbers, its association with *Palaeoloxodon antiquus* and *Stephanorhinus hemitoechus*, both Last Interglacial species, is therefore potentially significant; *Palaeoloxodon antiquus* is also found in the pre-Elsterian period (e.g. Pakefield [Preece and Parfitt 2012]) but in smaller numbers (Lister 1996).

- *Looking at the small numbers of specimens identified to species, is there anything that can be inferred?*

Proportionally, the collection exhibits 78% (n=14) post-Elsterian species with 17% (n=3) from species that span the Pleistocene and only 5% (n=1) pre-Elsterian. What is interesting about the combination of these two sets is the increase in the numbers of interglacial species relative to more northerly grounds. Here we have *Palaeoloxodon antiquus* (straight tusked elephant), *Hippopotamus* and *Stephanorhinus hemitoechus* (narrow nosed rhino); three species characteristic of the Last Interglacial (MIS 5e, c.125-115ka) in Britain (Currant and Jacobi 2001). There are therefore two apparent patterns in the dataset: one cold stage, typically

Late Pleistocene 'mammoth steppe' fauna and another interglacial, typically Last Interglacial fauna.

With the bulk of the specimens identified to *Coelodonta antiquitatis* (woolly rhinoceros) pointing towards an age of either MIS 8, MIS 7 or MIS 3 (Schreve 2001; 2004), and all of the other species (apart from *Mammuthus meridionalis* [southern mammoth]) also present during this period, this may indicate potential ages for the richest bone-bearing deposit, The Wallet. The large size of much of the deer material may lend support to this being during MIS 3, rather than MIS 7, as it has been noted that this species is especially large during this time (Jacobi *et al.* 1998; Currant and Jacobi 2001).

Similarly, *Stephanorhinus hemitochus, Palaeoloxodon antiquus* and *Hippopotamus* could indicate a Last Interglacial (MIS 5e) date for another of the smaller, less productive deposits.

Since it is known that these specimens are being recovered from more than one area of seabed it is not surprising that within this collection there are species which do not fit together in any known assemblage (e.g. *Mammuthus meridionalis* with *Coelodonta antiquitatis*). There is also the possibility that environments offshore may contain species groupings that we are so-far unfamiliar with, although for landscapes as proximal as a few kilometres off Clacton this seems less likely. At this early stage of identification, any groupings are tenuous, with the only species known in any kind of abundance being *Coelodonta antiquitatis* and therefore indicating a post-Elsterian age for at least some of the parent deposits.

- *Are there any historic specimens from comparable areas that can shed light on these patterns?*

The inclusion of faunal specimens trawled from the vicinity off Clacton and Harwich during historic times increases the overall sample to 275. Figure 5.12 shows that the relative proportions of the historic specimens identified to genus are similar to the more recently collected material from Colchester, with only very few of them falling into the grey (only to genus) category. Most of the historic collection has been identified to species level and so its inclusion can help to provide some kind of indication of the relative proportion of species' temporal distributions. The species which now dominate are *Mammuthus primigenius* (woolly mammoth), *Coelodonta antiquitatis* (woolly rhino) and *Palaeoloxodon antiquus* (straight tusked elephant). As with the Brand Collection, these species indicate a post-Elsterian date for bone bearing deposits in this area.

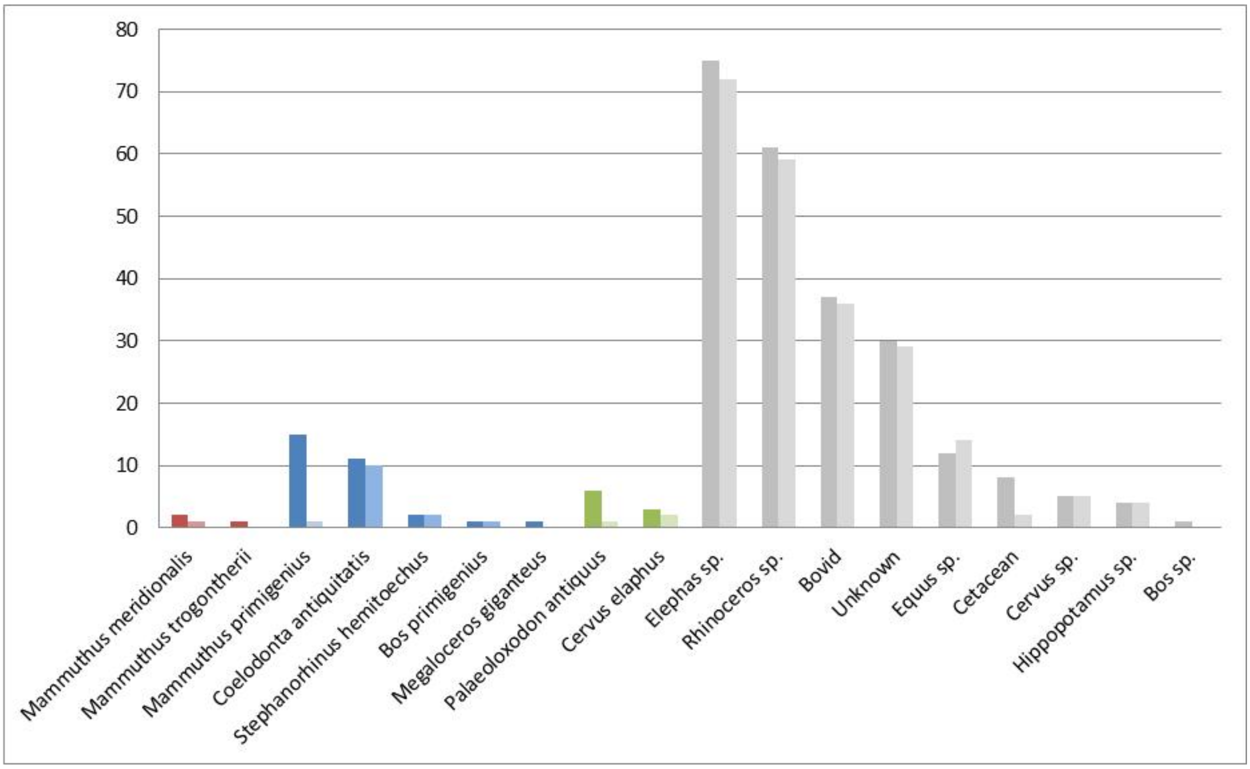


Figure 5.12 Faunal representation with historic specimens (left hand, darker coloured columns) and without historic specimens (right hand, lighter columns).

The collection is now dominated by *Mammuthus primigenius* (woolly mammoth), with 15 examples of *Mammuthus primigenius* and 11 of *Coelodonta antiquitatis* (woolly rhino). Although small in number, these 15 *Mammuthus primigenius* specimens represent 36% of those identified to species level, still reflecting this bulk of material in need of further assessment.

Proportionally the collection exhibits 71% (n=30) post-Elsterian species with 21% (n=9) from species that span the Pleistocene and 8% (n=3) from the pre-Elsterian. What is interesting about the combination of these two sets is, again, the increase in the numbers of interglacial (specifically MIS 5e) species relative to more northern grounds: here we have straight tusked elephant, hippopotamus and narrow nosed rhino. There are therefore two apparent patterns in the dataset: one cold stage, typically Late Pleistocene 'mammoth steppe' fauna and another interglacial, typically Last Interglacial fauna. Whilst these are patterns that hold true for the Brand Collection on its own, the increase in identified specimens that the historic collection gives makes these patterns more robust.

5.2.3.2 Bone patterns – condition and scalloping

Bone condition

The condition of the specimens ranges from light in colour and mineralisation to dark and more heavily mineralised (Figure 5.13). They also range in their level of abrasion, with some displaying more rounded edges than others. What this can tell us about the deposit they derive from is not certain, as bone abrades differently at different stages of mineralisation and it is often difficult to tell whether the abrasion is recent or not (Thompson *et al.* 2011). On the other hand, many of the bones display modern breaks (e.g. Fig 5.13c.), which are potentially a result of the traumatic process of being trawled from the seabed and dropped onto a boat.

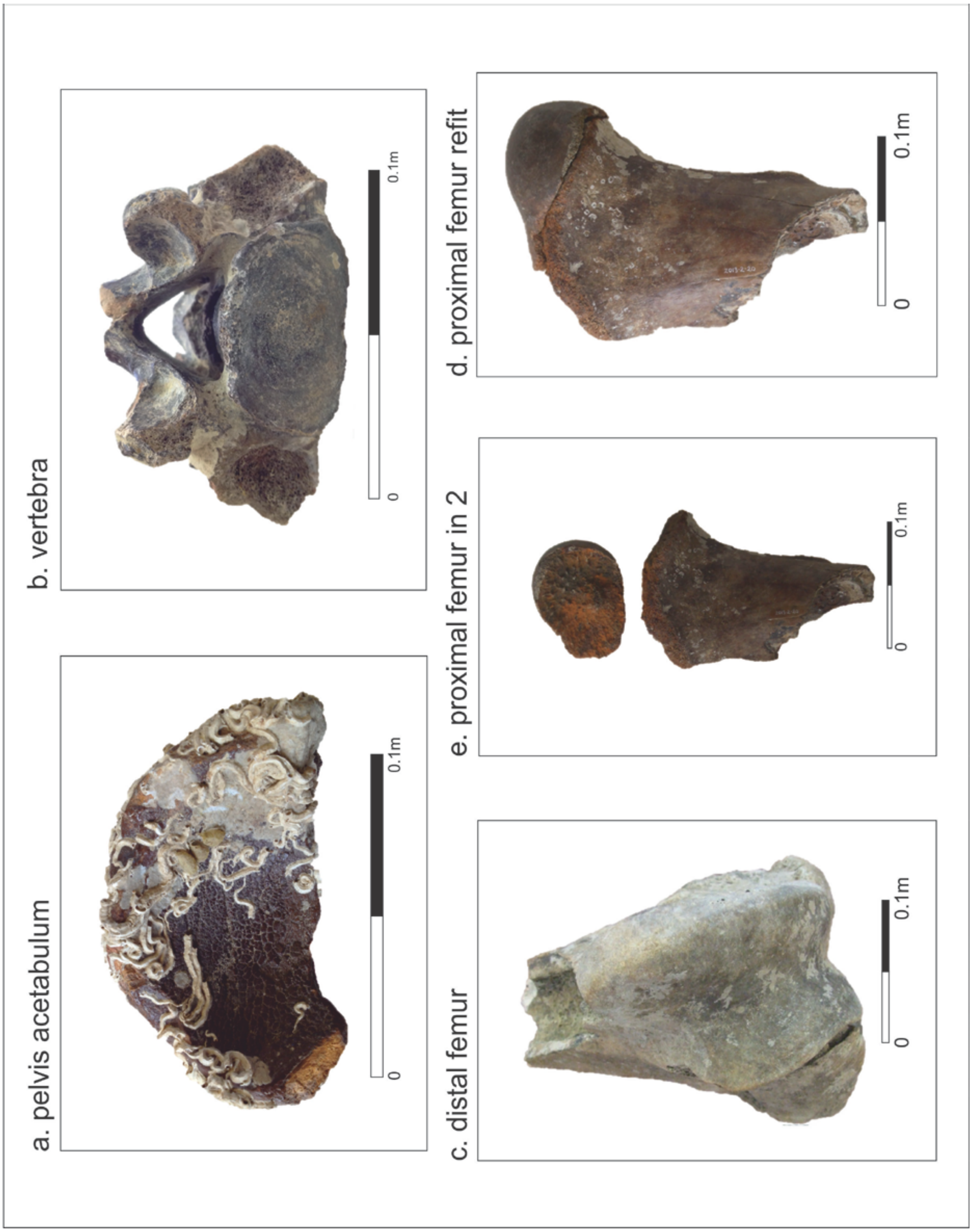


Figure 5.13 Series of bones from the Brand Collection, showing a range of conditions, colours and marine growth

Due to time constraints in the recording process the level of abrasion has not been quantified or recorded for all specimens, as such it is difficult to assess how, or whether, this relates to specific groups of fauna. Combining this with their degree of mineralisation and colour could be an interesting study for the future. The phenomena of 'black bone' from the North Sea (e.g. Hooyer 1957), and the use of this as some kind of age or deposit indicator, has been cautioned against due to the unreliability of assigning colour and the occurrence of these 'black bones' from a range of deposits (e.g. Drees 1986; van Kolfschoten and Laban 1995). However, when dealing with an assemblage of specimens from a defined area of seabed, investigating broad groupings within this category could still be useful.

Scalloping

A final point to note about this collection refers not to the species found or to their location, but to their condition. A significant number of the specimens (across all bones types) appeared to have had their cancellous (spongey) bone been scalloped, or scooped, away. This occurs from a minor to a very significant amount (Figure 5.14).

A few questions are immediately apparent: first, do they relate to anthropogenic activity or to post-depositional taphonomy? And secondly, in either case, what would be the purpose, or cause, of this? No archaeological examples have been seen from any other sites either from experience (Parfitt pers. comm.) or from a search of the literature. In terms of human groups utilising this part of the bone, it seems reasonable to expect that it would be on a larger scale, with all of the cancellous bone exploited, not just parts of the cancellous bone scooped away. Furthermore, humans exploiting these ends would be more likely to smash the cancellous bone open and not need to rely on eroding it away gradually, as appears to be the case here. Other archaeological examples come from carnivore consumption due to their grease content (Marean *et al.* 1999), but in these cases the entire ends of the bones are removed. The bones within the Brand collection do not exhibit obvious carnivore gnawing patterns, and, as stated, the cancellous bone appears to be scooped out, not gnawed away.

Figure 5.14 Scooped effect on various bones. a. a whale bone from an experiment in an aquarium, showing sea urchin grazing after a few years (Source: Nicholas Higgs); b. distal radius from the Brand Collection showing scooping effect; c. distal tibia from Brand Collection almost entirely scooped out.

In terms of post-depositional processes, the fact that this pattern has not been seen on any terrestrial sites implies that in this case it may be the result of marine organisms. Studies into deep-sea fauna (specifically *Rubyspira*) have shown the occurrence of a scooping effect, but this is on a much smaller scale and relates to faunas that exist in entirely different conditions (Johnson *et al.* 2010). One example that has been highlighted through these searches, but which is very under-researched, is the potential for sea urchin grazing. Discussions with researchers at Plymouth University have revealed that, although there is no grazing on such a big-scale shown in the literature, this is in fact known to occur (Figure 5.14a [Higgs and Pokines 2013]). At present this is thought to be the most likely cause of this phenomenon, and potentially relates to the type of seabed present in the area. Future work into this may be useful for looking at refining seabed locations using marine organisms that are either present (see Section 4.1.2) or inferred from these kinds of exploitation.

Further issues to tackle in the future relate to the identification of elements. These problems were to do with preservation of identifiable portions as well as the erosion or aspects of the bones making exact measurements reliable. Moreover, the measurement categories per species are reliant on few specimens, leaving little room for within-species variation to be recognised. In terms of taking this further, it is important that these bones are compared with reference collections, in order to get a more secure idea of morphological features than is possible from photographs. Other groups of species will be analysed in the future with the help of faunal experts from the Natural History Museum, London (Simon Parfitt and Adrian Lister).

5.3 **Discussion**

The two higher resolution case studies presented within this chapter demonstrate the potential of this derived faunal material for locating discreet areas of extant Pleistocene deposits. The inclusion of a modern collection shows that despite many years of trawling the seabed, this resource is still very much in existence. Furthermore the identification of the higher resolution pattern from the historic data is both unique and encouraging. Specifically, whilst the spatial accuracy may at times be vague, it can be usefully enhanced through the use of contemporary charts.

What do these more refined areas tell us about the submerged resource?

With these assemblages deriving from discreet locations there is the potential to say more about their parent deposits based on the material they are producing. In contrast to the way that the broader analysis provides a large-scale picture of the offshore zone but, presumably, does not pick-up on fragments of deposits from less well-represented periods, these more refined locations should represent correspondingly refined deposits. Of course, deposits have the potential to be re-worked and become time-transgressive (e.g. the glacially reworked deposits towards the north of the southern North Sea [Jeffrey *et al.* 1988]) but this cannot be known without further investigations of the deposits in question. There is also the issue of background noise, with the Area 240 project demonstrating an approximately 70:30 ratio of specimens deriving from the deposit to specimens that were extraneous (Russell and Tizzard 2011). This 'noise' in the deposit is an interesting concept, potentially explaining the discrepancies seen within expected assemblages, for example, the sole *Mammuthus primigenius* (woolly mammoth) found among the pre-Elsterian remains off and around Happisburgh.

Understanding these patterns and the nature of the parent deposit has implications for the questions we can ask of the material they yield. In these two cases, this has so far been possible with the material from The Wallet, which is the first instance of the focused investigation of a Pleistocene deposit through the investigation of faunal remains. This will be discussed below with reference to the geophysical data collected for this location.

5.3.1 The Wallet

Current geophysical and geotechnical data demonstrate the existence of deposits from a range of dates in the area immediately offshore Clacton (Bridgland 1995; Bridgland and D'Olier 1995; Roe *et al.* 2006; Roe and Preece 2011; DONG Energy 2011; Dix and Sturt 2011). We know that there are palaeochannel deposits in the area dating from all the Middle Pleistocene interglacial periods (MIS 11, 9, and/or

7) with MIS 5e also represented (Dix and Sturt 2011). The onshore area further shows deposits ranging from the pre-Elsterian (which are non-archaeological [Preece *et al.* 1990]), to MIS 9 (Cudmore Grove [Roe *et al.* 2009; Roe and Preece 2011; Roe *et al.* 2011; Briant *et al.* 2012]) and MIS 5e (East Mersea Restaurant Site [Roe *et al.* 2009]).

The situation whereby there are a range of fragmentary deposits of different dates in close proximity is not uncommon, especially where there is re-activation of existing channel systems (e.g. Outer Thames REC project [Dix and Sturt 2011]). In some areas, younger migrating channel systems may have truncated the fill-deposit of older channels, exposing deposits of variable ages. What this does mean, however, is that the current situation of broad-scale mapping, and extrapolation from small numbers of boreholes and cores, is highly likely to be smoothing over this picture of complexity. The Wallet is a case in point, along with sites such as Area 240 (Hijma et al. 2012).

In terms of the specimens recovered from the seabed off-Clacton, we know – from Mr Brand - that approximately 80% of the total specimens have been recovered from the study area within the Wallet. Since it is not possible to know which specific faunal specimens relate to this 80%, the patterning within the collection as a whole has been analysed.

The assemblage appears to show three main things:

- It shows a dominance of species associated with the cooler 'mammoth steppe' environments present from approximately MIS 8 onwards such as *Coelodonta antiquitatis* and *Mammuthus primigenius,* although these species appear to be most prevalent in the Weichselian landscape.
- The combined remains of *Palaeoloxodon antiquus, Stephanorhinus hemitoechus* and *Hippopotamus* potentially indicate the exploitation of an Last Interglacial (MIS 5e) deposit. The very small signal of these species (although subject to change with further species assessment) potentially relates to a smaller area identified in a location which corresponds with a core of Last Interglacial date to the north-east of the study area (Section 1.2.2; Dix and Sturt 2011).

- Despite the existence of the Clacton Channel deposits and the distinctive nature of the Swanscombe MAZ (Holstenian/MIS 11), nothing specifically from this date has been recovered.

Given the proportions of a later Pleistocene assemblage relative to those which represent a potential Last Interglacial date, there is a strong chance that the deposit being exploited in the Wallet is representative of the former. Given the dominance of *Coelodonta antiquitatis* (woolly rhino) in the collection, it is likely that this was formed from MIS 8 onwards, but specifically in MIS 8, 7 or 3 (Schreve 2001; 2004). This is supported by the *Mammuthus primigenius* (woolly mammoth) remains which further point to cold, steppe landscapes during later stages of the Pleistocene and future analysis will aid these interpretations. The small proportion of possible Last Interglacial material is potentially coming from the area shown in Figure 5.5 that corresponds with core - VC15 (Figure 5.7) – which has been OSL dated to 116+/- 6.5 ka (Dix and Sturt 2011). At the very least, this demonstrates the fragmentary existence of Last Interglacial deposits in the vicinity.

From the swath bathymetry collected in the study area, the depths of the deposits interpreted as likely to be those yielding Pleistocene material are at approximately -10mOD. Within the onshore terrace gravels of the surrounding coastal locations, those that are measured at this depth (e.g. basal sands and gravels of the Cudmore Grove channel [although this unit (Unit 1) is potentially of a different origin: from a smaller river re-working Thames-Medway gravels], Shoeburyness Channel, Burnham Channel Gravels [Roe *et al.* 2009; Roe and Preece 2011; Briant *et al.* 2012]) are, through terrace stratigraphy, biostratigraphy and lithostratigraphy dated to a post-Holstenian interglacial, probably MIS 9 forming part of a large, dissected interglacial estuary (Roe and Preece 2011; Briant *et al.* 2012). Being over 15km away, height-based correlation with these deposits (that are at these depths at a maximum), would require almost no gradient across the now-submerged landscape. Their correlation is, therefore, uncertain and purely speculative but does provide hypotheses to begin thinking about and, with future ground-truthing and physical investigation, testing.

What is important to note, however, is the significance of this work as it stands, regardless of its potential for the future. Having geophysically investigated an area of seabed - targeted purely due to the recovery of faunal remains - and managed to link specimens to what appears to be a discrete area of Pleistocene deposits, is a substantial step forward in the way that we explore the offshore zone. In contrast to the reactive, chance-driven approach that we currently see, it represents the proactive, bottom-up approach that this research has been working towards.

5.4 Conclusions

This chapter has demonstrated how, from collections of derived Pleistocene faunal remains, it is possible to identify discrete areas of Pleistocene deposits on the seabed. The case of the Oyster Bed is an example of this from 19th Century finds, showing the potential of an array of historic sources for providing locations for groups of these specimens. The research in the Tendring Peninsula took this a stage further through targeted geophysical investigations of an identified bone-yielding locality, which provided encouragingly positive results. Combining this with wider offshore and onshore terrace mapping, and an analysis of the current species identification, indicates an array of variably dated Pleistocene deposits in the vicinity. Furthermore, the geophysical data shows the potential for identifying such deposits as distinct from both older, tertiary bedrock and modern, Holocene, unconsolidated deposits. The level of detail made available through this geophysical data emphasises the issues we face with the more widely available broad-scale geophysical mapping smoothing over pictures of complexity on the seabed. This therefore highlights the need for, and potential of, higher resolution investigation of seabed deposits, as well as the caution needed when basing interpretations on extrapolated datasets. This leads onto themes picked-up in the following chapter, specifically the use of offshore data in combination with known deposits and processes to assess the patterns seen through this research.

Chapter 6: Discussion

At the start of this research it was noted that the prevailing attitude towards pre-LGM archaeology in the southern North Sea is that it is entirely reworked, with resulting finds being unstratified and of little value (Flemming 2002). This attitude, which is reflected by the lack of engagement with submerged areas in the 100 years since Reid's *Submerged Forests* (1913), has resulted in our current interpretations of hominin interaction with them; they are little more than abstract ideas. Over the past decade, Palaeolithic research along coastal locations has been progressing (e.g. Parfitt *et al.* 2005; 2010; Ashton *et al.* 2008a), with occasional offshore sites such as Area 240 (Russell and Tizzard 2011) and the Zeeland Ridges (Hublin *et al.* 2009) slotting into this picture. However, work on all these sites has been responsive - carried out after chance finds revealed greater potential at a given location. While the significance of the finds made is hard to overstate, it is not possible to advocate a reactive 'luck based' approach to the investigation of this material as the most efficient or practical means of answering key questions with regard to the Palaeolithic of North West Europe.

The research presented in this thesis comes at the matter from a different angle, one which aims to create a more focused, bottom-up and proactive approach. Reliant on this, however, is the establishment of a baseline understanding of the resource available, a resource which falls into two categories: that of the archaeology and that of the landscape. Recent years have seen the latter benefit from increased coverage via Regional Environmental Characterisation projects as well as engagement with broader industry datasets (e.g. Gaffney *et al.* 2007; 2009), and these have increasingly demonstrated the existence of pre-LGM deposits in the southern North Sea (e.g. Dix and Sturt 2011). The former, archaeological category, however, has seen little in the way of research. This thesis therefore set out to re-evaluate the existing artefactual record from the UK sector of the southern North Sea and its value to our understanding of hominin migrations, subsistence and occupation patterns.

Chapter Three demonstrated how the methods developed through this research can be applied to the existing (faunal) offshore resource. These methods have stemmed from the fact that most of the specimens were collected historically. Once the potential in the patterning of the resource was understood, the methods were then expanded and developed to include modern collections. Through a new understanding of the integrity of the specimens' parent deposits, we can therefore begin to engage with these areas in very different ways, using this prolific resource to start focusing on and exploring deposits of archaeological relevance. Whilst the results from each analysis have been discussed within their respective sections, this chapter will look at the possible reasons behind these patterns, from collection biases to glacial erosion.

6.1 Contextualising the patterns

Chapter One asked two achievable questions of this research:

- *What is the nature of these specimens (of faunal material) and the deposits they are contained within?*
- *What do their distribution and patterning tell us about the offshore resource?*

These have been explored through Chapters Four and Five, assessing the types of material that make up the existing offshore record, the various methods that we can employ to interrogate it and the patterns seen as a result. Demonstrating spatio-temporal patterning to the resource has meant that a significant degree of integrity can be inferred for these deposits. Previous chapters have highlighted possible reasons for this patterning, and this section will explore them further, in order to assess their respective relevance to the research. First, the main patterns can be briefly stated:

- Both the northerly Great Yarmouth grounds as well as the more southerly Lowestoft grounds are dominated by post-Elsterian species (more specifically, MIS 8 onwards).

- The Lowestoft grounds have an increased number of pre-Elsterian and 'spanning' species relative to the Great Yarmouth grounds.
    - The Dutch work has a corresponding pattern for the same area (Figure 4.22).
- The coastal areas of East Anglia are dominated by pre-Elsterian species to the north, with later Pleistocene species dominating in the south.
- The Tendring Peninsula area has a small number of interglacial species which is at a relatively high proportion relative to the other collections.

In order to appreciate these patterns in their broader context, we have to discuss the formation and investigation of the deposits that contain them. This first section will evaluate how we can attempt to understand these deposits, the processes that have determined their distribution and the resulting implications for the patterns seen.

6.1.1 Data issues in the offshore zone

As with the terrestrial realm, to understand the offshore Palaeolithic archaeological record requires an understanding of the associated geology; the two are very much intertwined. Developing an understanding of the nature of the deposits that the specimens derive from, and their occurrence on the seabed, therefore relies on successful determination of any correlations. In terms of the buried deposits of the offshore zone this engagement is almost invariably through seismic imaging, its interpretation tested by occasional cores. Whilst the situation onshore is one of a relatively rich record of physical investigation and well-mapped deposits, the offshore zone is of a lower resolution with much extrapolation. Consequently, whilst developments in seismic imaging have allowed the mapping of vast areas of seabed - far larger than anything that would be possible onshore – for the most part this has been at the expense of the finer-grained interpretations that we, as archaeologists, often rely on.

The broad-scale pictures developed for the offshore zone since the 1980s (e.g. Cameron *et al.* 1992; Limpenny *et al.* 2011), which present extensive polygons for long periods of time as 'marine' or 'glaciolacustrine', for example, almost certainly miss the smaller-scale pictures of deposits within the blocks. The in-depth analysis and interpretation of Area 240 and the Outer Thames Estuary, Humber and East Coast REC projects, recognising multiple-age deposits, are cases in point. Moreover, the use of extant museums' collections to recognise a discrete Pleistocene bone-yielding deposit of 1km x 3km in the Wallet, presented in Chapter Five, further demonstrates the scale at which these deposits exist and at which they can be recognised. It is important to remember, therefore, that when dealing with these offshore geological datasets we are working with estimations and extrapolations from a small sample of known points. Figure 6.1 illustrates this, showing a large number of geophysical lines which have been ground-truthed by only a handful of cores. Given the fragmentary nature of Pleistocene deposits, both onshore and offshore - and increasingly so with increasing time-depth - the potential for smoothing over expressions of alternate landscapes is clear.

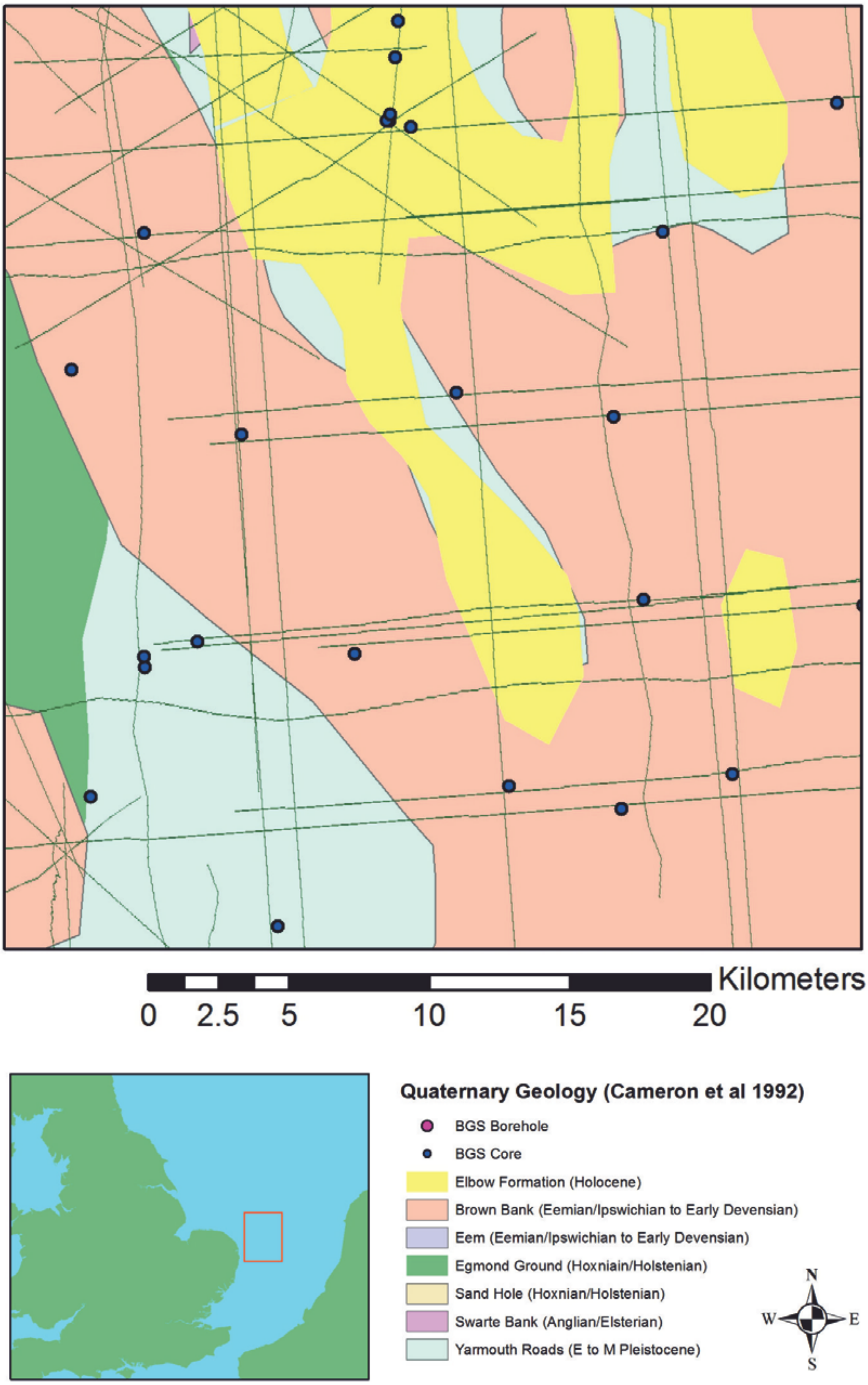


Figure 6.1 British Geological Survey geophysical line and core spacing: an example of extrapolation. (Source: www.bgs.ac.uk)

In addition the level of detail shown by these geophysical techniques depends on the reasons for the capture of the data, an issue well illustrated by recent archaeological analysis of geophysics from the Dogger Bank (Gaffney *et al.* 2007; 2009; Fitch *et al.* 2011). Using seismic data collected by oil companies, this work identified and characterised an unprecedented area of submerged landscape relating predominantly to the early Holocene period. The resolution of the data used, however, was relatively low, as the deposits that the oil companies are interested in are far below those relevant to the archaeologist; there is a trade-off between depth and resolution. Furthermore, the cores used to complement the geophysical data were widely spaced (Bailey 2010). Despite the fact that this work has revolutionised what we know about the Mesolithic landscapes of the Dogger Bank and how we can go about interrogating them, there is a clear requirement for more finely-tuned, archaeologically-focused data collection if we wish to move understanding forward. This has significant implications for the work presented here, which, through a large faunal resource, attests to a range of broad environments from a range of Pleistocene periods, but which also relies – in part - on an understanding of seabed deposits in order to further understand the higher resolution images that emerge.

Given the patterns seen through the specimens, the broad picture of later Pleistocene, cold-stage dominance is therefore likely to be both a pattern that we would expect but also a potential product of the scales at which we image the seabed. More focused investigations utilising faunally derived patterns are required to determine the relative importance of each of these points for individual areas of the seabed.

6.1.2 Deposits and processes

The Quaternary deposit models which characterise the offshore zone, despite being rather broad-scale, are currently the best means by which we can understand the area. So, in addition to considering the geophysical limitations, it is vital that we understand the various taphonomic factors that may have affected the distribution and preservation of deposits. The erosion of large portions of palaeogeographic evidence for periods before the late Weichselian (MIS 2), however, means that it is hard to draw out the relationships between sea levels, ice volume and topography. Moreover we have very little concept of isostasy prior to the LGM at present, we can really only look at mapped ice extents, global ice volume and our modern bathymetry to create best-fit images of likely land-sea configuration. Reconstructions of the changing landscapes of the Early and Middle Pleistocene are therefore full of caveats. There are two means by which this can be addressed:

- First, the most recent glaciation, the late Weichselian (MIS 2) is by far the best understood. It lies within the range of radiocarbon dating and features the deposits most recently laid down. Using this as a proxy, we can attempt to understand how the landscapes changed through earlier glacial periods: the dynamic interplay between land, sea and ice.
- Secondly, we can combine modern bathymetry with mapped glacial limits and global sea levels to create these best-fit images. Whilst this is crude, it helps to conceptualise the landscapes as they changed through time (e.g. Coles 1998).

If we appreciate these issues we can address questions about how Palaeolithic deposits may have been affected by the repeated glaciations and inundations, what these glaciations meant for the configuration of terrestrial landscapes and, consequently, how this relates to the patterning identified through the research.

6.1.2.1 The late Weichselian as a proxy

Seismic evidence from tunnel valleys in the North Sea basin indicate that it may have been glaciated on as many as seven occasions between MIS 13 and MIS 2: at times in quick succession – possibly within interstadials of the same broad glaciation (Stewart and Lonergan 2011). Evidence that these were extensive throughout the southern North Sea is patchy, but we can infer that this area was at least periglacial or steppe-tundra landscape for much of these periods. Furthermore, the associated development of features such as pro-glacial lakes

(Toucanne *et al.* 2009a; Murton and Murton 2012) will have had a significant effect on the configuration of the landscapes as well as the preservation of underlying deposits.

These glaciations will all, of course, have been different, but it is fair to assume that the associated processes will have been similar and, by using the higher-resolution records of the late Weichselian as a proxy, it is possible to get an idea how dynamic and oscillatory the ice sheets were. Evidence from the late Weichselian maximum suggests that the British Ice Sheet (BIS) and Fenno-Scandinavian Ice Sheet (FIS) coalesced in the North Sea basin between the Dogger Bank and western Denmark and that the ice extended to the north-western edge of the continental shelf (Figure 6.2; Sejrup 1994; 2000; 2009; Carr *et al.* 2006; Graham *et al.* 2007; Bradwell *et al.* 2008). It is important for this work, however, to ascertain the effect that the glaciations would have had on the configuration of available land and, in particular, the situation moving into and out of glacial maxima: periods more conducive to floral and faunal – including hominin - occupation.

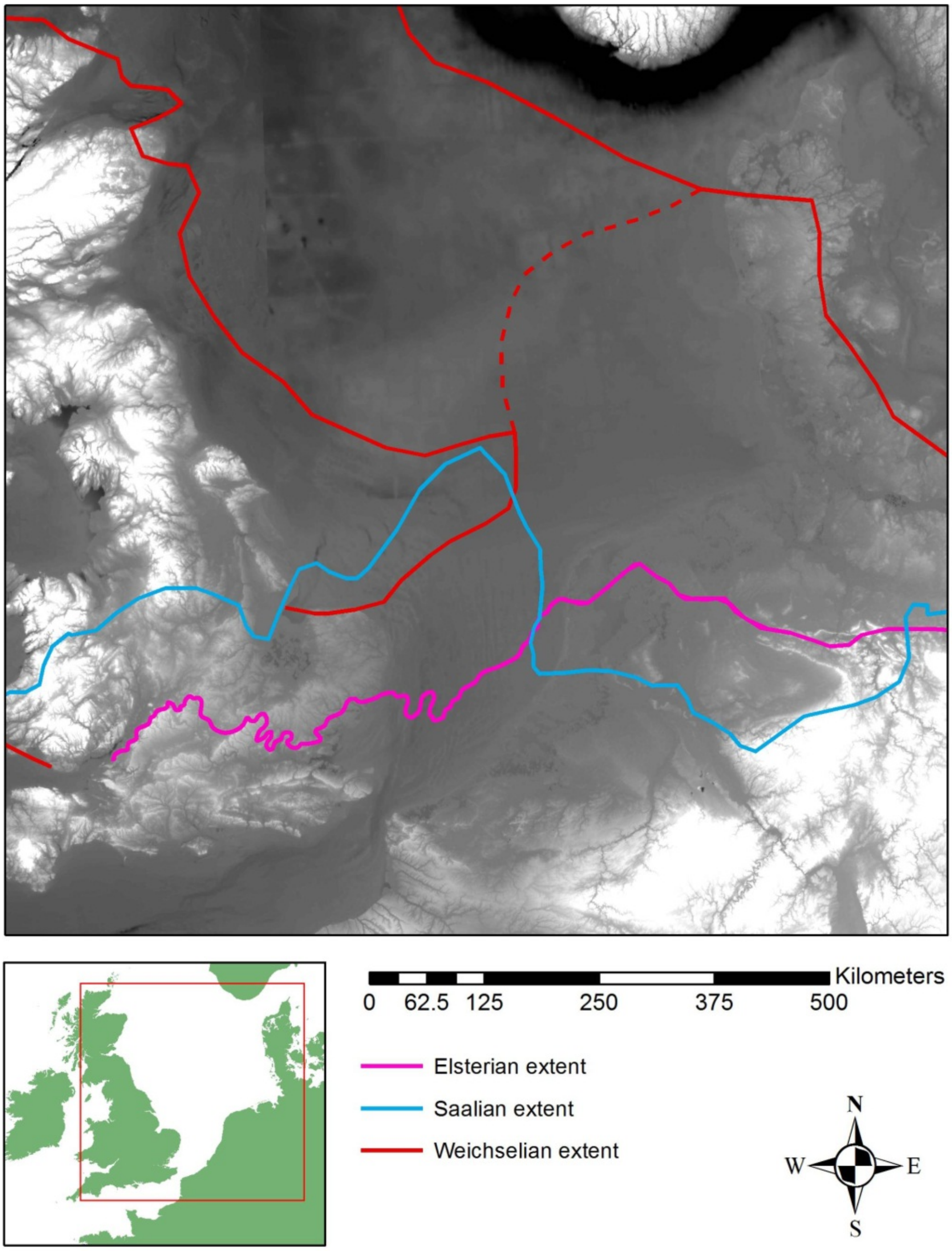


Figure 6.2 Maximum glacial extent for the Elsterian, Saalian and Weichselian glaciations (after Graham *et al.* 2011; Lee *et al.* 2012. Elevation source data: Smith and Sandwell 1997)

Impact on land

The deglaciation of the late Weichselian in the North Sea was widespread but still characterised by still-stands and occasional re-advances (Graham *et al.* 2011). The relationship that these changes had with sea levels was not linear, and although rises in sea levels appear to have influenced the break-up of ice at the deeper northern shelf-edge, the southern North Sea remained dry land for many thousands of years; the Channel and North Sea were not confluent until 9-7ka BP (Graham *et al.* 2011). This pattern of ice retreat, with marine incursions from the northern North Sea potentially acting as a catalyst (Bradwell *et al.* 2008), implies that whilst ice sheets still inhabited the northern parts of Britain and the North Sea the areas to the south were fit to be occupied, probably in part because of the shallower bathymetry of the southern North Sea in relation to its northern extent. This is supported by the earliest incursions of post-LGM hominins at approximately 14ka cal BP (Jacobi and Higham 2011) and through into the Mesolithic. These are, of course, *Homo sapiens* - our understanding of the climatic tolerances of earlier hominins cannot be directly correlated – but evidence that our earliest ancestors occupied sites such as Happisburgh 3 and Boxgrove (Section 2.3.1; Roberts and Parfitt 1999; Parfitt *et al.* 2010) in cooler climates implies that they coped with harsh environments from an early date. Furthermore, Neanderthal sites such as Biache-St-Vaast and Veldwezelt-Hezerwater in Belgium during MIS 6 of the Saalian Complex show occupation of these landscapes during glacial and interstadial periods (respectively Tuffreau and Sommé 1988; Bringmans 2007).

Applying this patterning to earlier periods suggests that the later stages of de-glaciation may have been associated with faunal, floral and hominin re-occupation of north-western Europe before fully interglacial conditions prevailed. This is especially pertinent to periods after the initial breaching of the Weald-Artois ridge in MIS 12 (Gupta *et al.* 2007; Toucanne *et al.* 2009), which were associated with basin depths increasingly lowered as a result of progressive subsidence (Busschers *et al.* 2008): it is hypothesised that the basin floor has subsided from 0 to -40m OD since MIS 11 (Ashton *et al.* 2011); ever more substantial drops in sea level were therefore required to create dry land and connection. In addition to the long-term subsidence experienced by the North Sea basin, however, more directly related glacio-isostatic movement associated with the loading and unloading of the crust by ice will have altered the elevation and configuration of specific areas of land. Although for the pre-LGM period the specific ways that this would have played out for Pleistocene environments is not understood, using the LGM as a proxy indicates that in places this would have been on metre to decametre scales (Brooks et al. 2011; Sturt et al. 2013). This would not only have altered land in a terrestrial/marine way, but would have changed the finer qualities of these areas: the nature of the ecologies and environments (Sturt et al. 2013). The terrestrial availability that this configuration implies, therefore, would have had significant implications for occupation of both Britain and the southern North Sea basin before subsequent transgression.

In addition to this issue of terrestrial availability, however, is the effect that the ice sheets will have had on the previous deposits. Although in some cases, such as the Cromer Forest bed Formation along the coast of East Anglia, glacial till can work in favour of preservation (Cohen *et al.* 2012), sub-glacial processes are also extremely erosive. The patterns of subglacial drainage in the form of tunnel valleys, mapped extensively across the North Sea and adjacent landmasses, are one example of this (Huuse and Lykke-Andersen 2000; Stewart and Lonergan 2011), with the damming and subsequent overtopping of pro-glacial lakes as inferred for MIS 12 and MIS 6 (Gupta *et al.* 2007; Gibbard 2007; Toucanne *et al.* 2009) and the resulting erosion seen through the Dover Straits and Channel another, larger-scale example. Deposits formed previously, which have been subjected to later glaciations, are therefore likely to have been either capped and buried, or eroded.

6.1.2.2 How can we relate these issues to the patterning seen in this research?

Figure 6.3 shows the locations of the main fishing grounds in relation to the mapped extents of the three major Pleistocene glaciations: the Elsterian, the Saalian and the Weichselian, with the grounds of the Lowestoft trawlers being by far the least impacted. If we combine this with what we know about their species patterning we can see that the areas that have been affected by several glaciations have a reduced temporal range of fauna. There are two possible reasons for this:

- Having been subjected to at least three glacial advances (possibly up to seven in some locations [Stewart and Lonergan 2011]), the deposits have been entirely eroded or reduced to extremely fragmentary expressions.
- Owing to the continued subsidence of the North Sea basin, they are buried below more recent deposits.

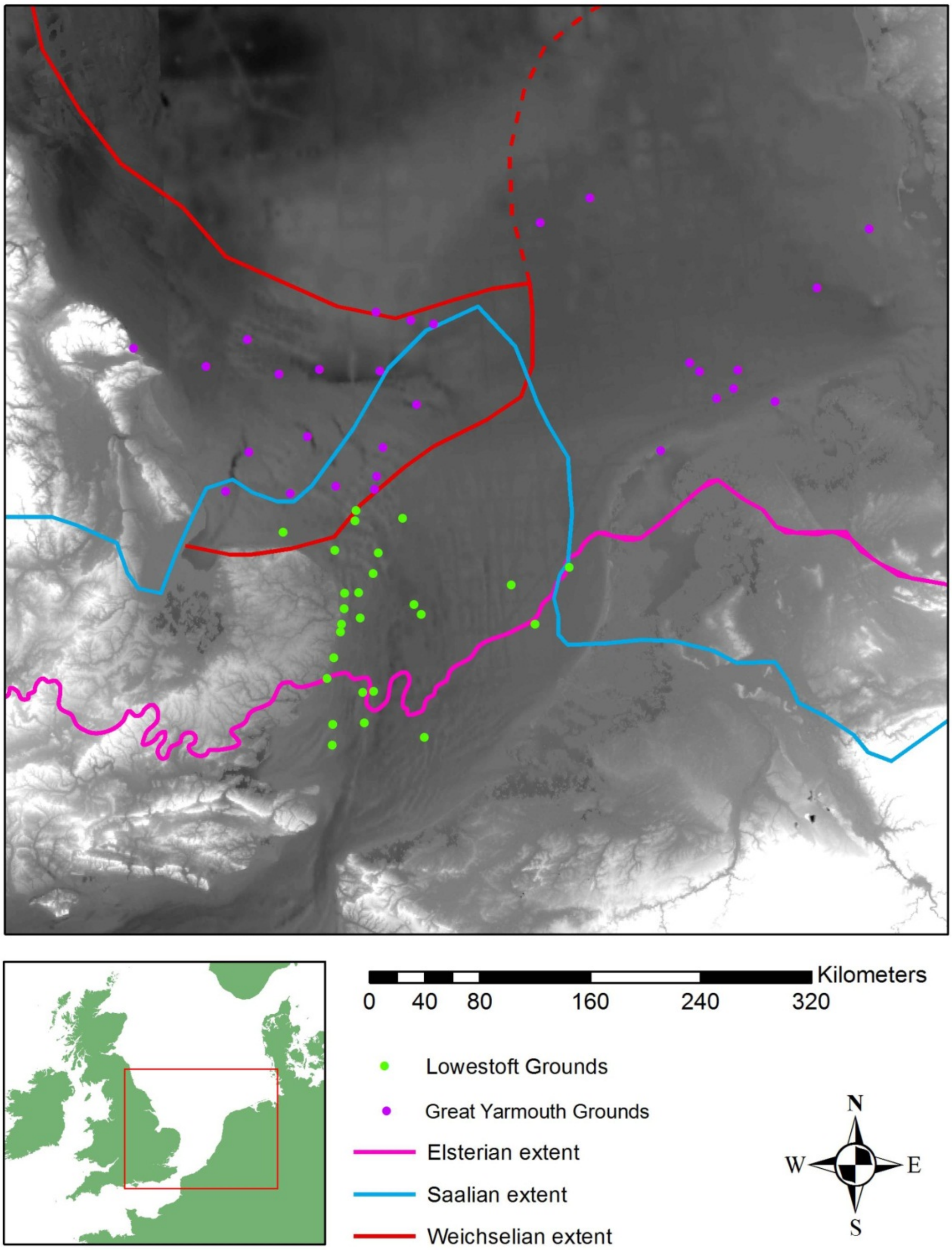


Figure 6.3 Glacial extents and their relationship to the favoured fishing grounds identified in Chapter Three (ice extents after Graham *et al.* 2011; Lee *et al.* 2012, elevation data: Smith and Sandwell 1997).

With the change during the Elsterian from the southern North Sea being a predominantly depositional, deltaic environment (depositing the Yarmouth Roads Formation) to one dominated by glacial landforms and deposits (Cameron *et al.* 1987; Graham *et al.* 2011), the thickness of the deposits from the post-Elsterian is far reduced (Cameron *et al.* 1992). Deposits forming throughout this time would have been subjected to trans- and re-gressive episodes, as well as cyclical patterns of glacial erosion, particularly in the northern-most section. For them to be extremely fragmented is therefore perhaps more likely than their extensive preservation and burial. If that is the case, the most extensive deposits are therefore likely to be those of the Yarmouth Roads Formation and those that formed more recently, during the Weichselian. The deposits of the intervening interglacial periods are likely to be relatively lacking and, as shown in Chapters Four and Five (as well as Section 6.2.1), this does appear to be the case. Furthermore, with glacial effects felt most severely in the northern sector of the North Sea basin, and actual glacial limits (after the Elsterian, MIS 12) appearing to stay to the north of the Dogger Bank and the north-west section of the Netherlands (Figure 6.3; Graham *et al.* 2011), the deposits to the south of these limits could be expected to show a relatively greater temporal diversity as a result of being subjected to fewer episodes of direct glacial erosion.

The dominance of Weichselian deposits to the north of the southern North Sea is supported by reports that the Dogger Bank area consists of reworked Pleistocene glacial deposits overlying those of the Yarmouth Roads and Swarte Bank (MIS 12) Formations, and covered by early Holocene tidal flat deposits (Jeffrey *et al.* 1988; Fitch *et al.* 2005; Gaffney *et al.* 2007; 2009). This further supports the faunal picture of a significant dominance of later Pleistocene, cold-stage species from this location. In addition to suggesting glacial re-working, this highlights the two problems of subsidence-induced burial and of, often, thick Holocene deposits overlying those of the Pleistocene. This has important implications for the potential for the buried deposits to be retrieved by trawlers, and this will be returned to below.

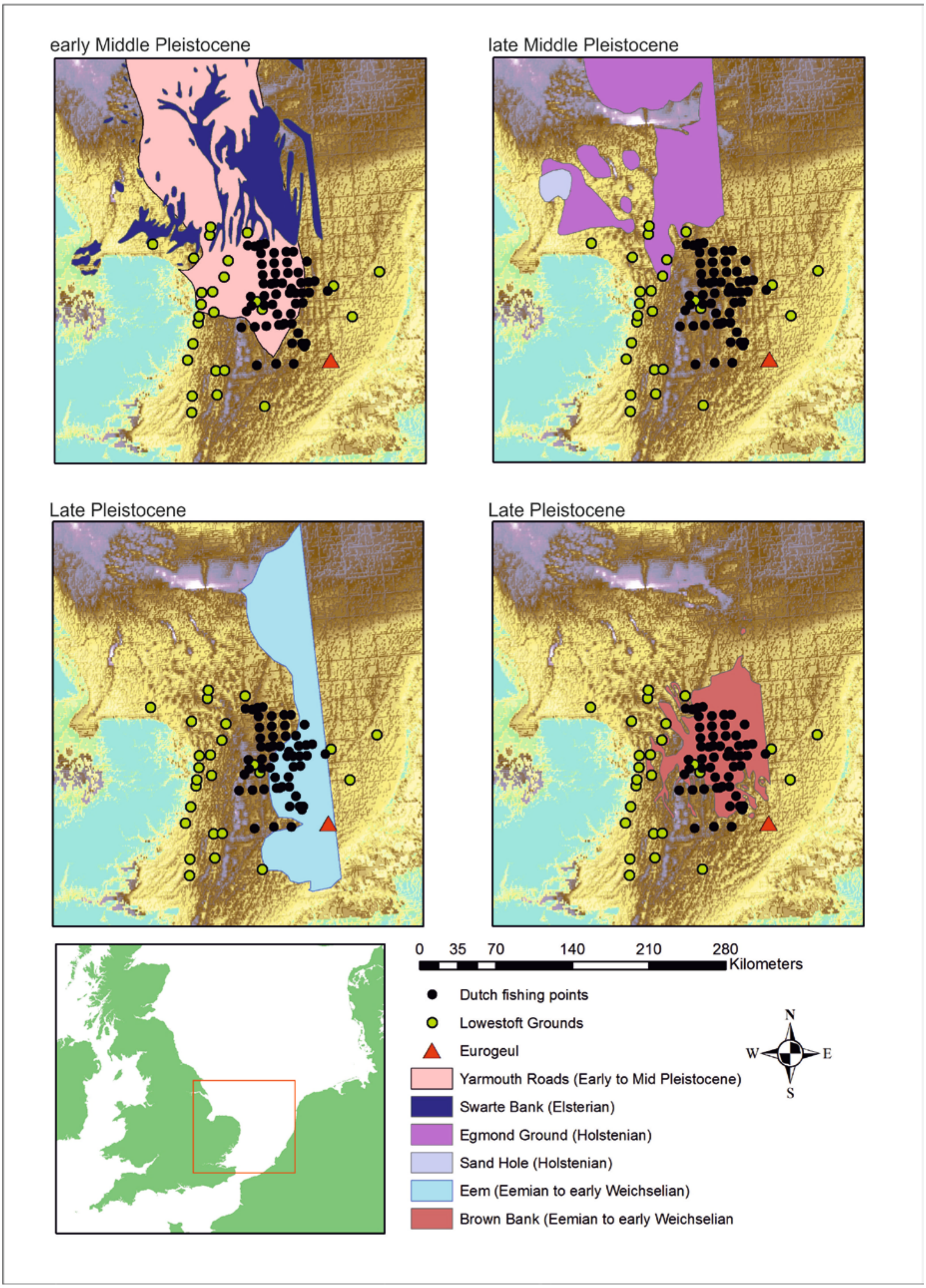


Figure 6.4 Mapped Pleistocene deposits in the southern North Sea and their relationship to the points mapped by van Kolfschoten and Laban (1995) as well as the Eurogeul (Mol *et*

al. 2006). (geological deposit data source: Cameron *et al.* 1992; Limpenny *et al.* 2011. Elevation data source: Smith and Sandwell 1997)

The extent, currently known, of the relevant Pleistocene formations is shown by Figure 6.4. It demonstrates the presence of both the pre-Elsterian, Early to early Middle Pleistocene Yarmouth Roads and Eemian to early Weichselian Eem/Brown Bank Formation deposits within the vicinity of the find spots from both Lowestoft and the Dutch trawlers. Given the recognition in this area of the Yarmouth Roads and Brown Bank deposits, it is interesting to note that no large-scale deposits of the intervening or younger Formations have been recognised and mapped. This perhaps explains the paucity of Holocene remains within the collections (those collected for this research, as well as: van Kolfschoten and Laban 1995), the dominance of later Pleistocene species and the smaller proportion of those from the pre-Elsterian.

What is important to note about these formations, which is significant to the recovery of specimens and the targeting of deposits, is the issue of outcropping. The large-scale deposit maps shown (Cameron *et al.* 1992; Limpenny *et al.* 2011) deal with the locations of Pleistocene formations, whether on the surface or beneath several metres of subsequent deposition. A major feature of the seabed in southern North Sea, however, is the varied scales of movement seen. First, there are areas of sedimentation that are broadly static over long periods. Secondly, there are large morphological features, such as the Wallet, whose margins may fluctuate slightly but which remain essentially in the same place. And, thirdly, there are areas of high seabed mobility. Whether the finds are from areas of high sedimentation or high mobility may affect how often deposits are exposed and, consequently, the likelihood of recovery through trawling. At this stage, it is impossible to pinpoint the historic finds to specific fishing grounds, but we can think about the proportions of seabed locations in various environments. If we combine the Wallet data, as well as other areas of bones recovered from the surrounding seabed, with recent investigations into sediment-transport in this area, it appears that the finds are being recovered from areas of high sedimentation but of varied levels of movement (Figure 6.5). This implies that deposits may be covered and exposed quite rapidly, and that may mean that some specimens recovered from this area are being trawled from relatively fresh deposits.

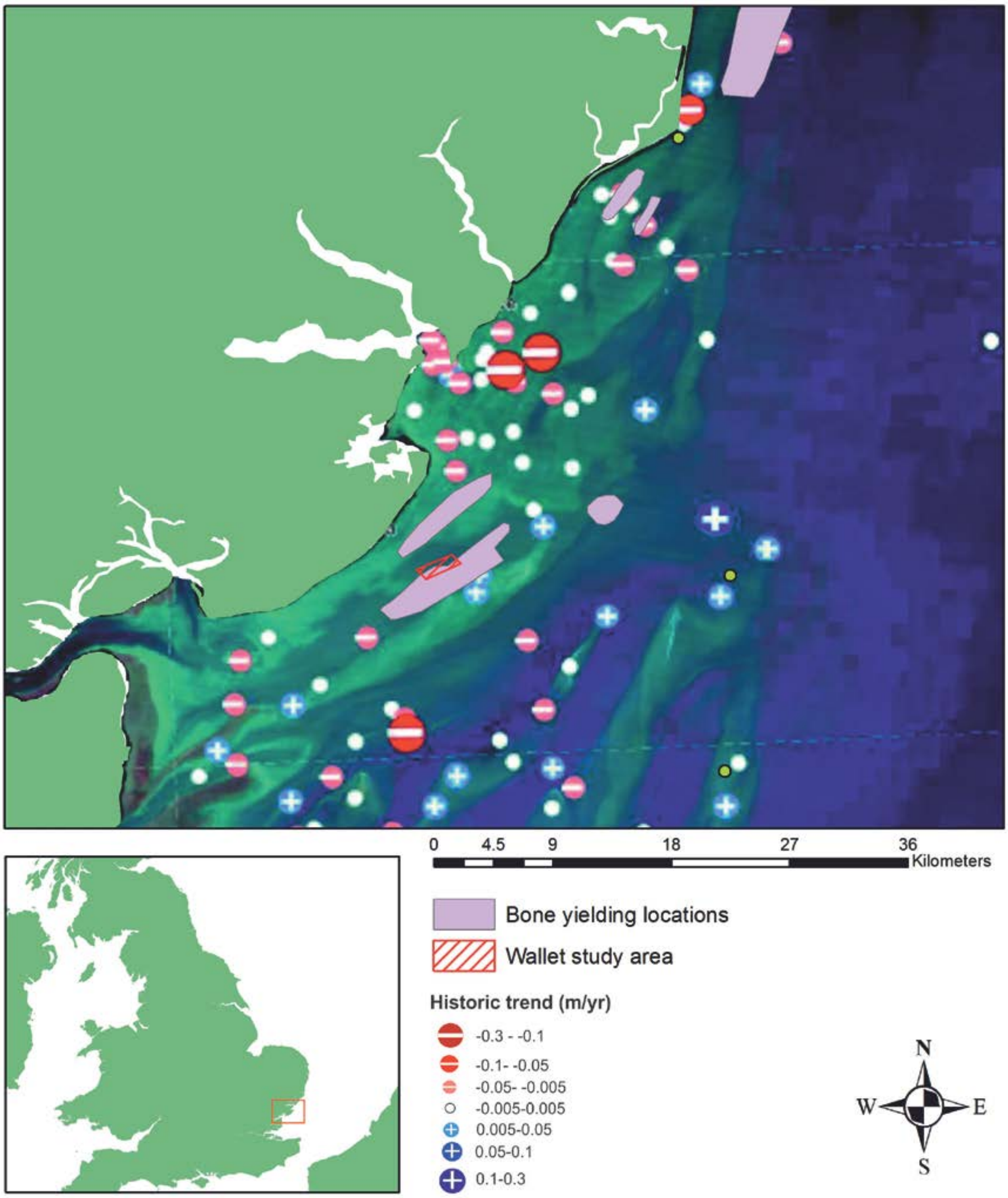


Figure 6.5 Rates of movement in metres per year in the Outer Thames Estuary and the relationship of this to the bone-yielding deposits presented in Chapter Five (after Burningham and French 2008)

6.1.2.2.1 Patterns of changing land/sea boundaries

At the heart of understanding the archaeology of these areas is the issue of reconstructing periods of dry land in the southern North Sea when climate would also have been conducive to occupation. The changing palaeogeography of the area throughout the early Middle to Late Pleistocene would have played one important role in this. Figure 6.6 demonstrates the inferred availability of terrestrial land for the early Middle Pleistocene before the initial Weald-Artois breach against a map of the modern bathymetric contours at -100m and -60m. This gives an idea of the availability of dry land associated with drops of this kind, which were common throughout glacial periods (even MIS 3 saw sea levels of approximately -60m - -80m [Shackleton 2000; Waelbroek *et al.* 2002]). Clearly, this relies on modern bathymetry, but, given that the sea-floor was at progressively higher elevations with increasing age, should present a conservative estimate.

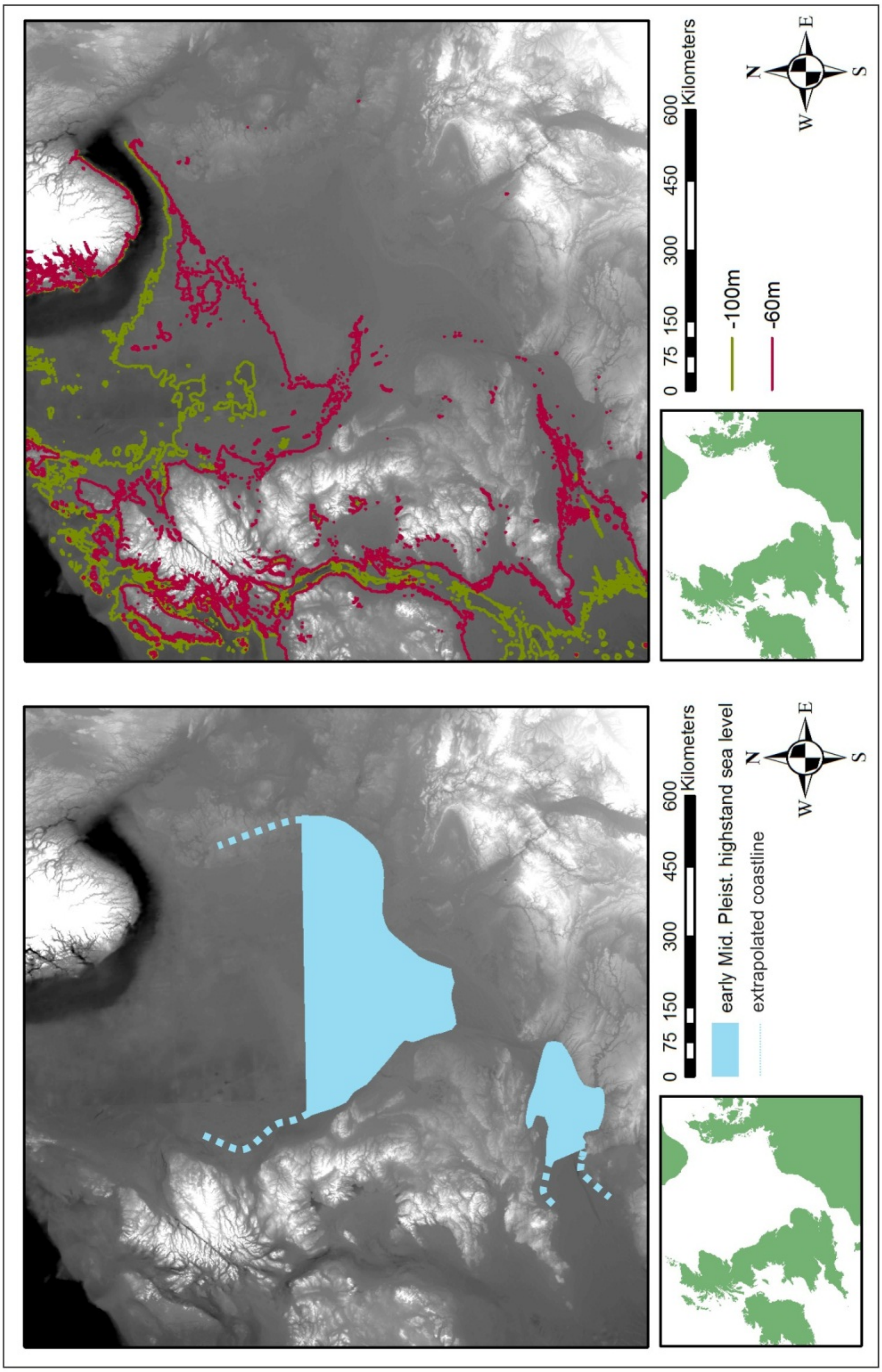


Figure 6.6 Difference in available landmass between the early Middle Pleistocene and the periods of lowered sea level discussed in the text. (Highstand sea level image after Hijma *et al.* 2012. Elevation data source: Smith and Sandwell 1997)

Although this does not take into account the presence of ice-sheets at points throughout glacial periods, the broad picture of low-stand landscapes would have been similar throughout the post-Elsterian (Hijma *et al.* 2012) and they would have extended further north than during the early Middle Pleistocene. The importance of this for the resulting patterning of specimens is twofold:

- The more northerly areas of the Dogger Bank were terrestrial on several occasions after the Elsterian period, but not terrestrial (or at least not typically so) during the early Middle Pleistocene.
- The more extensive landscapes available throughout the late Middle and Late Pleistocene will have undergone fewer episodes of submergence the younger they become, with deposits relating to the late Weichselian/post-Weichselian period (associated with the Mammoth Steppe fauna) being relatively undisturbed.

Consequently, the expected patterning from the southern North Sea would be one of younger Pleistocene species being more abundant towards the north, with an increasingly mixed pattern further south. Given the relatively recent formation of these deposits it is highly likely that Late Pleistocene deposits and specimens would dominate throughout. As discussed above, however, outcroppings of deposits of multiple ages should be expected. In terms of the results presented in Chapter Four and summarised at the start of this chapter, we see both these patterns.

Summary

There is clearly a multitude of landscape processes at play, which will have affected, and continue to affect, the Pleistocene deposits. Understanding their influence can help to broadly predict, or at least appreciate, the locations of offshore deposits and then the specimens that they contain. Added to this complex picture, however, is the issue of visibility. Whilst geophysical imaging allows us to engage with large tracts of these offshore areas in ways that we could never imagine for the onshore zone, its advantages come with their own attendant drawbacks, as it may smooth over the finer pictures that, as archaeologists, we are often most concerned with. The results of this research have indicated that concern about 'smoothing' over a more complex picture is indeed justified, as there appear to be fragmentary deposits of a nature that is unrecognised by current mapping. However, applying the methodology to draw-out smaller-scale patterns, in combination with higher-resolution areas of geophysical work, demonstrates that resolving these issues is certainly possible.

6.1.3 How does this relate to the patterns seen?

The faunal specimens derived from the southern North Sea and collated and presented through this research demonstrate significant spatio-temporal patterning, and, when combined with the factors referred to above, appear to show the patterns that we would expect. So, what does this tell us about the deposits from which the specimens were recovered? If you follow the argument that the faunal material recovered from the seabed is entirely out of context, and has been so for tens of thousands of years, you would not expect to see any patterning within the resource. If that were the case, the species that represent pre-Elsterian times should be approximate to those representing the post-Elsterian periods. That they do not could be argued to be due to preservation over such long timescales (although let us remember that none of these timescales is short, and erosive forces should have also significantly affected later Pleistocene species). But it is possibly also to do with the deeper burial of the deposits in question under others of more recent age. As a general idea, this is supported by broad-scale seismic mapping, which shows the Yarmouth Roads Formation of the early Middle Pleistocene to be largely buried by more recent Pleistocene and Holocene deposits (Cameron *et al.* 1992, fig. 93). As discussed above, however, smaller, unmapped fragmentary outcroppings are not just possible but likely.

Potentially, the specimens' condition could reflect their depositional histories. Recent work looking at the preservation of bone in aquatic environments has shown differences in wear patterns depending on the age of the bone, with archaeological and fossilised bone weathering less quickly (Thompson *et al.* 2011). It also demonstrates that bones caught up in bedload movement are subject to the most erosion, with those that develop scour pits having reduced surface wear. In future, this, alongside patterns of marine growth on bone surface, may help to determine whether specimens are being recovered out of *in situ* archaeological deposits which have become recently exposed, or whether they are out of context and being regularly moved around the seabed. Significantly for the current research, the specimens do not exhibit weathering or erosion patterns that are related to their age, which indicates that they are (at least in large part) being trawled directly from their parent deposits, not as loose material.

The dominance of species that represent cold stages, such as *Mammuthus primigenius* (woolly mammoth) and *Coelodonta antiquitatis* (woolly rhino) relative to interglacial species such as *Palaeoloxodon antiquus* (straight-tusked elephant) probably relates to the palaeogeographies of these areas in high-stand to low-stand periods. As discussed in Section 6.1.2, large portions of the southern North Sea basin would have been terrestrial during post-Elsterian low-stand periods, with now-submerged terrestrial deposits from high-stands likely to have formed mainly close to modern coastlines (Hijma *et al.* 2012). The exception to this picture is the deposits of parts of MIS 11, 9 and 7, with the discrepancies in evidence pointing to marine incursions as opposed to connection to the continent, as discussed in Chapter Two. It is clear that throughout these interglacial periods Britain was periodically joined to the continent it is just not clear how or in what way, with even the early cold-stage of MIS 7 showing evidence for persisting high sea levels (Bates *et al.* 1997; 1998; 2000; 2003; 2010). As discussed, however, terrestrial deposits from these interglacial periods are rarely recognised in the offshore zone (cf. Urk Formation [Hijma *et al.* 2012]) and no distinguishing species have been found within the collections. Such period-specific species exist for the Eemian, such as *Hippopotamus antiquus*, as well as the Holstenian: *Dama dama clactoniana* and *Ursus spelaeus.* If either any these species were identified within collections, that would strongly indicate deposits of these dates. The recovery of *Hippopotamus sp*. specimens from the grounds off Clacton, discussed in Chapter Five, alongside *Palaeoloxodon antiquus* (straight-tusked elephant) and

Stephanorhinus hemitoechus (narrow-nosed rhinoceros) appears to indicate, therefore, that there are bone-yielding Eemain deposits being exploited in the vicinity. The further distinction between *Hippopotamus antiquus* (pre-Elsterian) and *Hippopotamus amphibious* (post-Elsterian [specifically, Eemian]), if possible, will secure this further, but the presence of deposits of Eemian date in a location where bones were recovered (Brand pers. comm.; Dix and Sturt 2011) strongly suggests that this is the case. The lack of species indicative of the Holstenian implies either that the deposits are lacking (not extant or buried) or, possibly, that they have not yet been identified. The proximity of the Holstenian-aged Clacton Channel deposits in the foreshore implies that it may be the latter.

The patterns identified throughout this research sit well with the dominant patterns that are expected from the offshore zone, with the abundance of cold-stage, later Pleistocene species probably deriving from the most prevalent and outcropping deposits. The picture of a smaller proportion of interglacial and earlier Pleistocene species demonstrates the existence of fragmentary deposits from more marginal, high-stand locations generally unrecognised by broad-scale seismic mapping. Crucially, this is a pattern supported by high-resolution work in Area 240 (Russell and Tizzard 2011) and the Outer Thames Estuary (Dix and Sturt 2011; Chapter Five: the Wallet).

6.1.3.1 Coastal areas

Chapter Five concentrated on two locations where higher-resolution pictures have emerged, the Happisburgh Oyster Bed and the Tendring Plateau, specifically the Wallet. Aside from demonstrating the potential for the remains to pinpoint such refined locations, these areas allow us to further investigate the spatio-temporal patterning of the small-scale coastal deposits. With the northern coastal section dominated by pre-Elsterian species, and the south increasingly by later Pleistocene species, what does this tell us about the nature of the seabed deposits in these areas?

The existence of the Oyster Bed in the near-shore zone is likely to be related to outcroppings of Cromer Forest-bed extending into the submerged zone in the vicinity of Happisburgh. Reasons for the excellent preservation of these extensive but fragmentary deposits, explored by Cohen *et al.* (2012), have been discussed in Chapter 2 and may relate to serendipitous capping by Elsterian till, so as to avoid the major erosive forces associated with the breaching of the Elsterian pro-glacial lake and being outside subsequent glacial limits. In addition to this, many facies of the CFbF appear to be iron-rich, as described by Reid (1890) and currently witnessed, which increases the chances of bones within this matrix being preserved. What are the possible reasons behind the geographical patterning of this deposit offshore, as seen through this research?

Figure 6.7 shows the predicted high-stand coastlines during the early Middle Pleistocene. Given what we know about the deposits in this area, that they are associated with complex patterns of channel systems, often within the estuarine zone, it is not surprising that, at the level of north Norfolk, these are the deposits that are currently being mapped in the coastal (Parfitt *et al.* 2010; Bates pers. comm.) and offshore zone (Dix and Sturt Pers comm.). Areas of the southern North Sea more to the south are more likely to yield such deposits further offshore, as shown by the mapping of the Yarmouth Roads Formation and the recovery of pre-Elsterian species by Dutch trawlers (Figure 6.3).

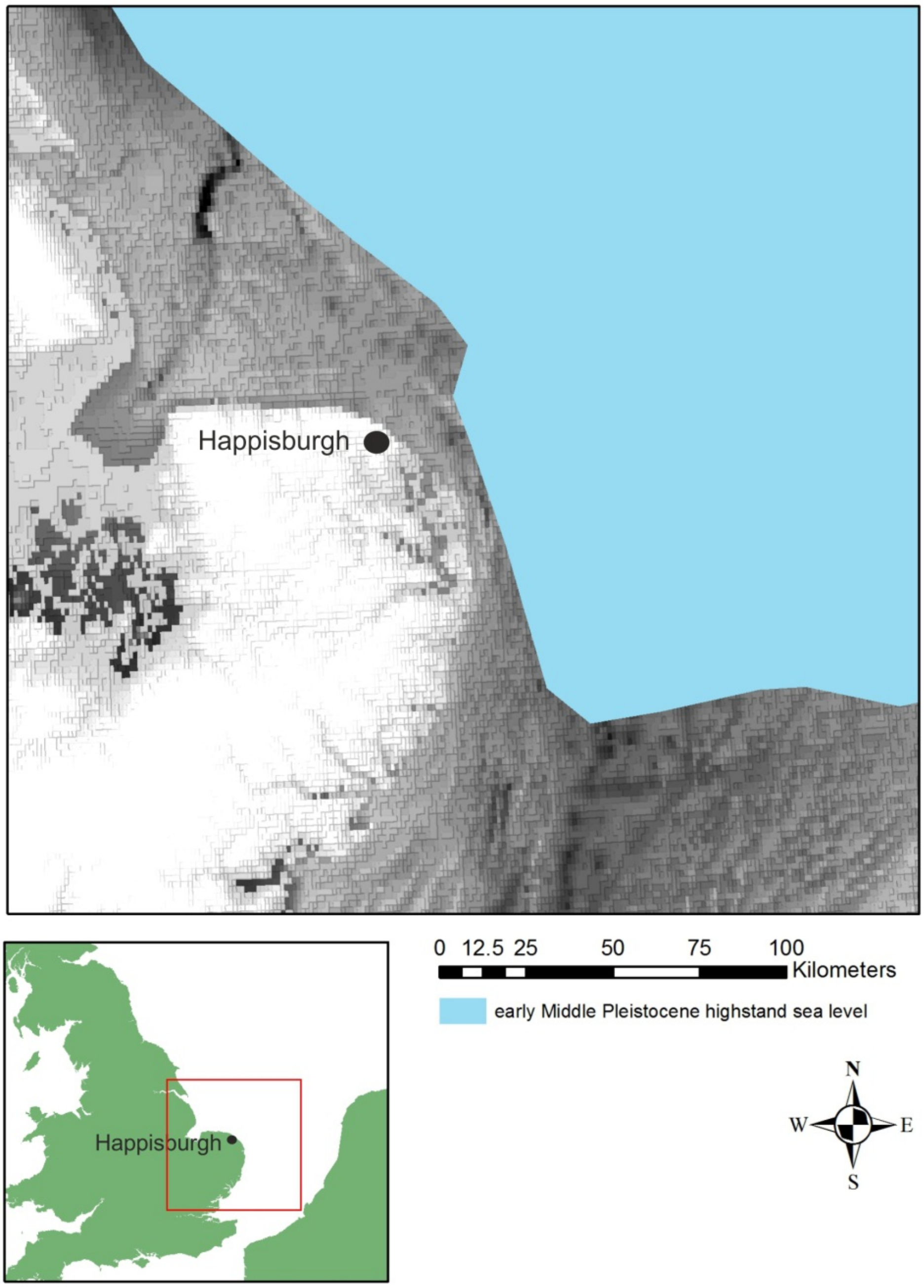


Figure 6.7 early Middle Pleistocene highstand seas (after Hijma *et al.* 2012) in relation to East Anglian coastline. (Elevation data source: Smith and Sandwell 1997)

Off the Clacton coast, in areas where we know a range of Pleistocene (and earlier, e.g. Pliocene Crags) deposits exist (Dix and Sturt 2011), are the deposits discussed in the Tendring Peninsula section of Chapter Five. Faunal analysis currently points to a date from MIS 8 onwards for the majority of these specimens, which are representative of a mammoth steppe fauna. In contrast to the early Middle Pleistocene deposits, therefore, and bearing in mind the lowered sea levels throughout much of the Late Pleistocene, the deposits associated with these remains are likely to have been spatially extensive.

Swath bathymetry data collected for the 1km x 3km study area within the Wallet – where the vast majority of the bones were recovered from – has shown what have been interpreted as Quaternary sediments at the south-western extent of the study area. Potentially associated with the margins of local channel systems, the clear demarcation of these deposits within the study area further refines the size of the seabed to begin groundtruthing.

What explanation can then be offered for the north-south spatial patterning in the two areas? The extensive nature of the glacially-capped early Middle Pleistocene CFbF deposits towards the northern East Anglian coast relative to deposits from any other period prior to the Holocene is probably the answer. Whereas towards Essex the offshore deposits are dominated by the migrating and multi-stage fluvial and estuarine deposits associated with the Thames-Medway system, where fragmentary deposits from a range of periods are preserved, eroded and/or buried by subsequent activity, the extant deposits from the northern shores are dominated by the erosion of the CFbF from cliff, foreshore and offshore deposits. Whilst these two periods both represent significant periods of time (the CFbF actually covers a far longer period from approximately 1.8ma until 0.48ma [Preece and Parfitt 2012]), the change in the nature of glaciations and dominant landscape processes after the Elsterian (Rose 2010), as well as the intensity of research into the later deposits (usually archaeologically based) and more refined dating techniques (Walker 2005), means that distinguishing between the deposits of the post-Elsterian, late Middle – Late Pleistocene is comparatively easy, providing a more detailed picture.

The fact that these deposits are close to shore may be the reason both for their preservation and for their discovery. If we discern the different trawling patterns from smaller-scale locations we can identify and analyse specific groups of material that would otherwise be subsumed within the broader dataset. In effect it is like being able to analyse distinct groups of fauna from the broader collections, having secured them to a small group of trawling grounds.

The current invisibility of small-scale deposits is a situation that, with the application of modern methods, can change. Building relationships with the modern trawling industry, as the Dutch have been doing, and recording where and when bones are recovered, will allow a far better insight into the offshore landscape fragments.

6.1.4 Social implications

The processes discussed above determine the deposits that are extant in the southern North Sea and so the types of specimens that we are likely to derive from them. In addition to the locations of the deposits, however, is the way in which they are recovered from the seabed and the interplay between the influence of the type of deposits being exploited (i.e. Pleistocene or otherwise) and the social factors relating to the trawlermen collecting them. To return to some questions posed in Chapter Three, then, what implications do the locations of deposits have for trawlers recovering and collecting fossils and for the resulting geographical patterns of these remains?

Chapter Three presented the discrepancy between the lack of collections from the north-eastern museums with the abundance from East Anglia, Essex and London. Several reasons were hypothesised:

- Differences in trawler design (beam as opposed to otter) which were linked to differences in means of powering the vessel (sail as opposed to steam, respectively);
- The methods of trawling (fleeting as opposed to shorter duration trips);
- The means of vessel ownership, related to the methods of trawling (company ownership and fleeting; personal ownership and shorter duration trips);
- The dominance further north of reworked glacial deposits, rather than environmentally and archaeologically rich interglacial deposits, leading to a

lack of interest, or absence of communities of collectors, and therefore to less incentive for trawlers to recover fossil material.

- The north-eastern fleets exploiting grounds to the far north, beyond the terrestrial limits of the Pleistocene.

The collectors described in Chapter Three (Text Box 5) were all wealthy, well-educated men who lived along or close to the East Anglian coastline. They were also intimately related by marriages, friendships and as mentors to each other. In this area, as well as the nearby large urban centres of the south, were natural history societies promoting and encouraging interest in the subject (such as the Suffolk Institute of Archaeology and Natural History [1848]; Prehistoric Society of East Anglia [1908]). The proximal location of the deposits of the fossiliferous CFbF appears to have played an important part in forming and promoting this interest. So did the many local quarries, exploiting the aggregate-rich geology.

In contrast, the northern towns of Grimsby and Hull were not close to quarries exploiting Quaternary materials nor to the extensive deposits of the CFbF but had local Quaternary geology largely dominated by glacial material. From the early 19th Century, however, they began developing societies. Hull saw the development of the Hull Literary and Philosophical Society in 1822. In the same year the nearby city of York developed the Yorkshire Philosophical Society and a few years previously (in 1819) Leeds developed the Leeds Literature and Philosophy Society. These societies, despite their names, concentrated largely on natural history (then known as ‘philosophy’). An interest in trawled fossils would seem to be in keeping with this, yet no material has been found in the collections of the local museums. For the Hull society, this may have something to do with the fact that the museum housing its collection was bombed in 1943, resulting in the loss of most of the artefacts as well as registers (Imrie pers. comm.). Recently, it has been found that minutes from local council meetings - since the society’s establishment - contain information about museums’ acquisitions and so, through future work, may help to clarify this issue further. But the other local societies appear to show the same pattern. The annual reports of both the Leeds and the York societies refer only to Pleistocene faunal material that has been recovered terrestrially from gravel pits or, at best, coastal deposits. Interestingly, the deposits that these come from are overwhelmingly those at and around Happisburgh and are even recorded as being donated by East Anglian collectors such as James Layton (York Phil and Lit 1823).

In part, then, the lack of trawled material in the north-eastern towns appears to be a combination of differing collection interests and, possibly, the loss of collections that had been curated. This, combined with the social aspects of the trawling industries in these areas - long, laborious and dangerous weeks of fleeting in the employment of owners who did not appear to care about the poor conditions, contending with drunkenness and fighting between (and among) fleets - may not have been conducive to the time, space and spirit for retrieving and storing fossils. With no major incentive from the communities at their ports, this may have been enough of a reason for these trawlermen not to bother collecting material. The avid collectors present at Great Yarmouth, on the other hand, would have given the trawlermen the incentive they needed. The shorter-duration trips out of Lowestoft, although still subject to the general dangers of trawling, are likely to have been more suited to the recovery of fossil material. Shorter working periods, better conditions and self-ownership would lead to a greater degree of control over what was kept on-board and subsequently sold. In addition, for Lowestoft as with Great Yarmouth, there was an abundance of local collectors providing an economic incentive for the trawlermen to bring back their fossils.

6.1.4.1 Trawling terrestrial deposits?

The social aspects described above present reasons for the lack of collections from the north-eastern ports, but is this the whole picture? Is it really feasible that over nearly 200 years of trawling, no fossil finds were recovered and curated and survived the bombing of WWII? The following will address this problem from the perspective of seabed deposits that the fleets of trawlers were inadvertently exploiting and the effect that this may have had on the resulting pattern.

As discussed above, how we map sea levels throughout the Pleistocene is often based on broad global data, tied in with relative sea-level proxies and therefore much of what is shown for the offshore zone is extrapolated from a few known markers. Furthermore, how this ties in with glacial extents is difficult to decipher for the earlier glaciations. The extension of glacial limits across much of the northerly areas exploited by the north-eastern fleets has been shown in Section 6.1.2.2. This would clearly have had a detrimental impact on the existing deposits, whether through burial or erosion, and may be part of the reason for the lack of faunal material from these towns. In addition, sections throughout Chapter Two discussed the approximate sea levels throughout MI Stages, which can help us to visualise the related changes in landscape and the potential locations of habitable Pleistocene land; Figure 6.8 shows these modern contours at -40m, -60m and -100m. Despite being based on modern bathymetry, and not taking into account the level of potentially co-occurring ice sheets, this shows that even a drop of 40m creates a significant amount of dry land out of the southern North Sea basin. If we take into account the subsidence discussed in Section 6.1.2.2 (0 to -40m OD since MIS 11 [Ashton *et al.* 2011]), any contemporary basin depth will have been elevated in relation to today, so that these contours are conservatively estimated.

When these levels are considered alongside the finds that have been recovered from different fleets, it is clear that the most northerly grounds exploited from the north-eastern ports would have been dry land only at the most extreme low-stand points (often associated with glaciation), if at all. Furthermore the increasing distances travelled by the north eastern fleets, with journeys over to the Barents Sea and Greenland made possible by the adoption of steam power (Figure 6.8, insert), mean that the deposits being trawled would also be increasingly non-Pleistocene. On the other hand, drops of only 40m would have created dry land in the southern North Sea out of the areas exploited by both the Great Yarmouth and Lowestoft fleets.

The glacial extents discussed in Figure 6.3 also appear to have had an effect on the deposits exploited and are shown in relation to the contours in Figure 6.8. From this distribution it is clear that whilst the northernmost grounds have been glaciated at least three times (see Section 6.1.2 [Stewart and Lonergan 2011]), and the Great Yarmouth grounds have been glaciated at least once or twice, depending on their east-west location, the Lowestoft grounds have only had one main period of glaciation during the Elsterian, with the Saalian reaching a few of the most north-easterly grounds (see Beets *et al.* 2005 for evidence of glaciation of the Southern Bight during MIS 8).

It complicates matters, however, that the north-eastern ports were also known to exploit the grounds on and around the Dogger Bank; indeed the discovery of these banks was the driving force behind the ports' development (Butcher 1980; Robinson 1996). So their use of grounds beyond the reach of terrestrial Pleistocene deposits can only explain in part their lack of specimens. As to this, a potentially significant pattern emerges from looking at the patterning of the glacial limits in Figure 6.8. We know from the specimens recovered that the vast majority are from the Late Pleistocene, either because of repeated erosion or burial. We also know that the area of the Dogger Bank, where the clustering of the eastern Great Yarmouth grounds are shown, is dominated by reworked glacial deposits overlain by Holocene tidal flat deposits (Jeffrey *et al.* 1988; Fitch *et al.* 2005; Gaffney *et al.* 2007; 2009). It may be that the most productive grounds for Pleistocene specimens therefore lie outside the limits of the Weichselian and further to the east, towards the Dutch coast. If this is the case, this would help to explain the lack of specimens recovered by the north-eastern fleets, as even while they were exploiting similar grounds as were the Great Yarmouth fleets at certain times of year, the grounds may have been those easternmost grounds dominated by Holocene deposits.

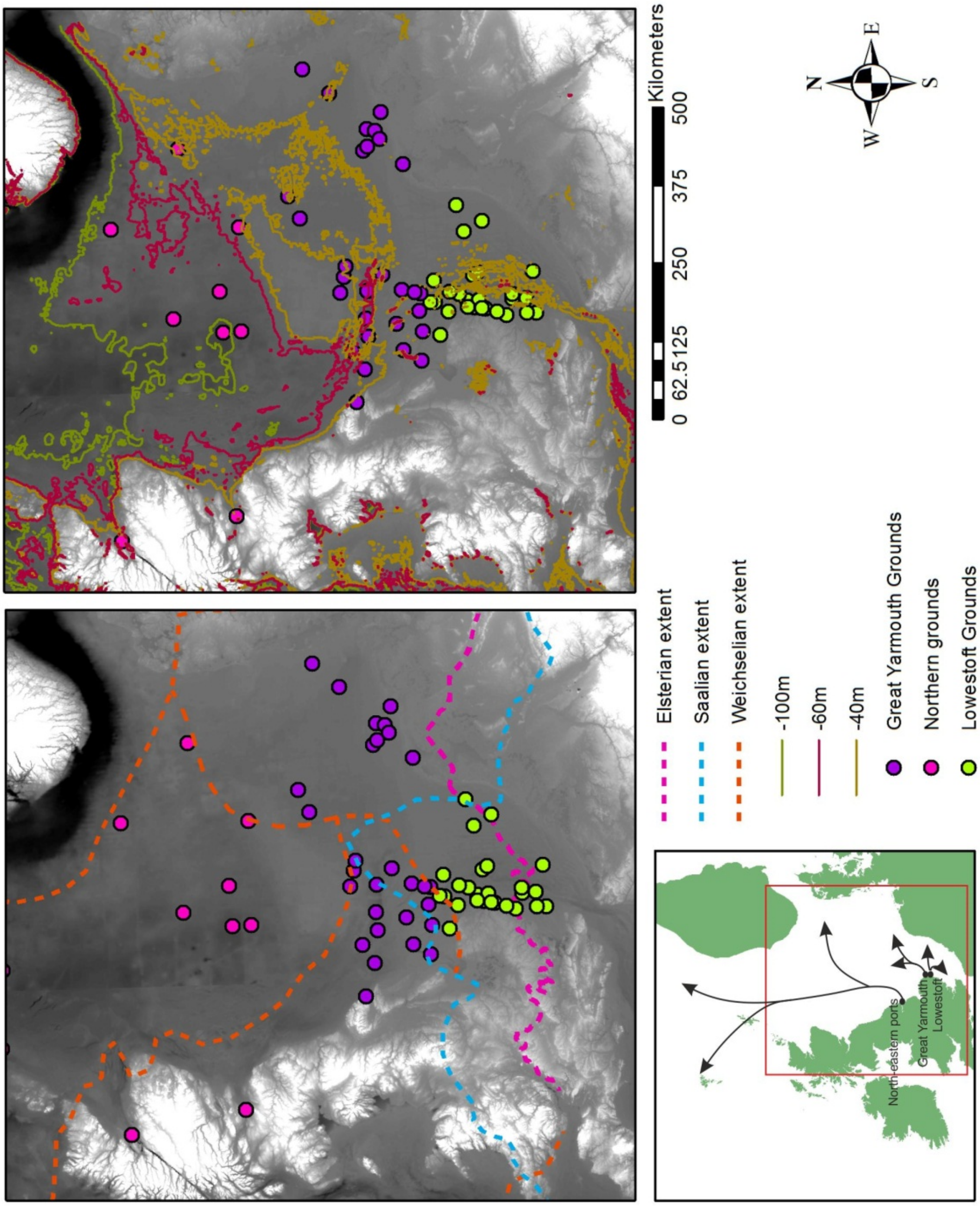


Figure 6.8 Position of northernmost, Great Yarmouth and Lowestoft grounds with relation to glacial extents on the left and contours, showing potential available landmass during low-stands, on the right. Insert shows the direction of travel and exploitation of the main trawling fleets. (Glacial limit sources: Graham *et al.* 2011; Lee *et al.* 2012. Elevation data source : Smith and Sandwell 1997)

It appears, therefore, that the negative pattern in the north-eastern towns may be the result of the combined effects of several factors:

- A lack of interested collectors;
- The lack of incentive for trawler collection that this would create, and;
- The relative decrease in the amount of targeted seabed that would have had Pleistocene terrestrial deposits.

The dominance of cold-stage faunas within the collections from Great Yarmouth and Lowestoft can also be appreciated within the context of these figures, which indicate that the exploited areas were exposed for much of the Middle Pleistocene cold/low-stand stages, often when the area was apparently also free of ice.

6.1.5 Summary

The distribution and history of terrestrial deposit formations in the southern North Sea throughout the Pleistocene can be compared with the locations of trawling grounds in order to assess the broad ages of deposits that the trawlers exploit. In this section factors relating to the formation and preservation of the deposits in the offshore and coastal zones have been discussed, as well as to the social issues surrounding the recovery and collection of the specimens.

The temporal patterning of the observed species appears to correlate with the proportions expected for species for each of the broad areas. Specifically, the northernmost 'Great Yarmouth' group of grounds yielding fauna - those that were dry land only during Middle and Late Pleistocene low-stands - have the highest proportion of post-Elsterian species, and these all fit comfortably within the later Pleistocene 'mammoth steppe' fauna. The Lowestoft group, exploiting more southerly grounds, which have early Middle Pleistocene as well as later Pleistocene deposits, show a definite dominance of 'mammoth steppe' species, but with higher proportions of earlier and interglacial species. Lastly, the coastal areas demonstrate discrete locations yielding fauna from defined periods of time. These patterns imply that many of the deposits from which they originate are intact and have the potential to present us with a new level of insight into the archaeology, ecologies and environments of these submerged landscapes. The multi-scale detail further allows insight into the nature of the deposits offshore, implying relatively broad preservation of more recent deposits with fragmentary outcrops of earlier landscape.

The fragmentary preservation of the offshore deposits and the broad-brush nature of our comprehension of them mean that tying the broader collections into a more refined area of seabed is presently difficult. By using this analysis, however, to lay the foundation for understanding the broad patterns of these geographical areas, in conjunction with new work involving modern trawlers and more detailed analyses, we can begin to pinpoint and assess locations of potential on the seabed.

6.2 Species issues and fragmentary deposits

Three scales of approach have so far been defined by the current dataset: the broadest scale, applicable to the majority of the specimens recovered historically, the smaller scale identified from the historic data, which give a more localised location but are still ephemeral (e.g. The Oyster Bed off Happisburgh), and finally, the much smaller scale that can be identified from some of the modern specimen collections (e.g. Chapter 5: the Wallet). Within these spatial groups is the potential to identify both temporal and ecological patterning from the species identified. This section will first address the complexities of spatial patterns before looking at the ecological implications of some of the species recovered.

6.2.1 Species attributions and complex patterns

As discussed, analysis of the faunal specimens indicates a good degree of integrity for the deposits from which they derive and may allow us to pinpoint areas of high potential. There are difficulties, however, with the discrepancies between knowing the species-identifications of groups of specimens, knowing groups of locations from which these could have derived, and being able to assign the groups to the locations. Furthermore, an issue with the dominant temporal grouping is that it can be difficult to group post-Elsterian specimens into specific temporal groupings when their provenance is broad. This is due to the occurrence of specific species in different groupings throughout different periods. For example, although the dominance of *Coelodonta antiquitatis* (woolly rhino) and *Mammuthus primigenius* (woolly mammoth) may point to a Late Pleistocene, Weichselian assemblage, these species are also present together in the cold stage of MIS 8 and the latter stages of MIS 7 (Schreve 2001; 2004). So, although we can make inferences based on prevalence of certain types of species, such as 'mammoth steppe', and their likely time-frame, a margin of flexibility is required.

The species that span the early Middle to Late Pleistocene may also appear problematic because they are time-transgressive. Like all species, however, their lineages underwent both phenotypic changes as well as changes to their distribution and abundance. It is these changes that can help us to distinguish them throughout the Pleistocene. *Cervus elephus* (red deer), for example, is present today and was present during the Early Pleistocene. It appears in abundance throughout, but appears to have had a particularly large form during MIS 3 (Currant and Jacobi 2001). *Palaeoloxodon antiquus* (straight-tusked elephant), on the other hand, is present from the early Middle Pleistocene through until MIS 3, but its abundance clearly fluctuates: whilst it is seemingly present at sites such as Pakefield (Stuart and Lister 2001, but there are issues with its provenance, see Preece and Parfitt 2012), it is present in far greater numbers during the Late Pleistocene (e.g. Franks *et al.* 1958; Franks 1960; Stuart 2005).

Several of these spanning species occur within each of the broader datasets. Given that we know that large areas of the Dogger Bank are dominated by Late Pleistocene/Early Holocene deposits (Gaffney *et al.* 2007; 2009), the interpretation that the specimens within these assemblages derive from Late Pleistocene deposits (rather than late Middle Pleistocene) seems fair. The presence of pre-Elsterian species such as *Trichechus huxleyi* (walrus) and *Megaloceros savini* (giant deer), however, implies the existence of a multitude of unrecognised fragmentary deposits which, in this case, perhaps does not extend as far into the offshore zone as the subsequent deposits (Figure 6.2/6.7). The situation is clearly very complex, but a greater understanding of the patterning of species in combination with deposit models, especially smaller-scale and higher resolution ones, is gradually clarifying the picture.

The statistic revealed by the work in Area 240, which showed a 70:30 ratio of faunal specimens that were *in situ* to those that were effectively 'background noise', provides an interesting way of thinking about these complex patterns. Is this the kind of ratio we should expect to find in any situation, representing those bones which are, in fact, kicking about the seabed? Or is this an artefact of a heavily-dredged (and so disturbed) area of seabed? Presumably, the 'background' signal could be represented by specimens from any period, which could in fact fit with the broader assemblage pattern being seen. An assessment of the importance of this would therefore need to concentrate not just on species attributions but also on factors such as abrasion, marine growth, colour and degree of mineralisation, if we are to attempt to determine anomalous specimens within an assemblage (see Chapter 2, Section 4.1.2). At this stage it is unclear to what extent this statistic represents the rule as opposed to the exception, but it is certainly worth further investigation.

The patterns from the more refined areas demonstrate the preservation of deposits which are pre-LGM, and this supports the hypothesis that bone-yielding deposits of multiple ages are extant. The 'Oyster Bed' off Happisburgh demonstrates an Early to early Middle Pleistocene deposit, with recently-collected beach specimens from immediately south, at Sea Palling, also falling into an apparently later early Middle Pleistocene assemblage (Parfitt pers. comm.). The material from the Wallet also implies earlier assemblage groupings. Although the bulk of them do appear to form either a MIS 8/7 or MIS 3/2 assemblage, there are hints of an interglacial environment represented, possibly one of Last Interglacial date (from the presence of *Hippopotamus*, *Stephanorhinus hemitoechus* [narrow nosed rhino] and *Palaeoloxodon antiquus* [straight tusked elephant]). Nearby deposits have yielded estuarine fauna associated with regression after the Last Interglacial highstand, as well as supporting OSL (116+/- 6.5 ka) and AAR dates (Dix and Sturt 2011). In terms of their location, these correspond remarkably well with the given location of a seabed area that has yielded a small number of bones (Brand pers. comm.). Potentially, the small numbers of seemingly Eemian fauna described above have therefore been recovered from this area of seabed, which provides another possible area of investigation.

6.2.2 Ecological patterning

Taxonomic evolution has been used throughout this research as a chronological control on the groups of specimens recovered. Issues with this, in terms of many of their time-transgressive natures, have been discussed, but the ecological information that they can provide is also crucial to this research. Characterising and understanding the changing environments within which hominins went about their lives is arguably as important as understanding the archaeological proxies left behind. One without the other tells us little about the bigger Palaeolithic picture.

The level that submerged Palaeolithic research is now at, however, does not yet permit us to appreciate the finer aspects of dynamic ecologies, although this should form a vital aspect of future work. Rather it is one of a coarser picture derived from large-bodied, mainly herbivorous mammals. Broadly speaking, they fall into the categories of cold-stage as opposed to warm-stage fauna, with the cold-stage faunas heavily dominating the assemblage.

The robustness of the most dominant fauna, *Mammuthus primigenius* (woolly mammoth), clearly has a part to play in its abundance. The relative lack of *Palaeoloxodon antiquus* (straight tusked elephant) remains on the other hand implies that there are other factors at play. With *Palaeoloxodon antiquus* specimens remaining at a low-level of abundance throughout the collection, a low-level interglacial component is inferred. This is supported by the proportions of the other of the species present: examples include *Castor Fiber* (European beaver), whose presence indicates riparian, woodland habitats, and *Stephanorhinus hemitoechus* (narrow-nosed rhinoceros) an interglacial species often associated with *Palaeoloxodon antiquus*. As we discuss in section 6.1.1, this picture is likely to be due to higher sea levels resulting in the relative paucity of offshore interglacial deposits.

The prevalence of *Mammuthus primigenius* (woolly mammoth) is also significant from an ecological point of view as an early form of this mammoth - called the Ilford Mammoth – is especially abundant throughout MIS 7 alongside *Coelodonta antiquitatis* (woolly rhino). Although MIS 7 is, at times, cooler than previous interglacial periods (Candy and Schreve 2007), the presence of this species indicates that it is adapted to open environments, not simply to temperature. Its dominance is, therefore, not necessarily an indication of glacial environments, but of the increasing occurrence of the mammoth steppe from MIS 8 onwards.

One unusual pattern that has been noted here and elsewhere (Mol *et al.* 2006) is the large numbers of specimens of *Coelodonta antiquitatis* (woolly rhino) from the southern North Sea. This species, although having nowhere near the prevalence of *Mammuthus primigenius* (woolly mammoth), has a consistently high frequency and is proportionately especially high within the well-confined Wallet/Tendring dataset. Similarly, this dataset has a very high proportion of *Rhinoceros sp.* remains. It will be interesting to see if these specimens too fall into the *Coelodonta antiquitatis* category: their largely robust nature appears, so far purely as an impression, to support this.

Having these patterns recognised within two southern North Sea datasets may indicate that there was something about these ecologies that *Coelodonta antiquitatis* found preferable. From their skeletal morphology it is now clear that they were a grazing species, probably with fat humps on their backs – indicated by their long anterior thoracic spinal processes – similar to *Mammuthus primigenius,* which implies adaptation to seasonal variability (Khalke and Lacombat 2008). They exploited open grasslands as well as glacial tundra steppe (e.g. Ariendorf 1 [van Kolfschoten 1990; Turner *et al.* 1997]) and, although present during British cold-stands as well as cooler interglacial episodes, were most prolific throughout MIS 3 (Khalke and Lacombat 2008). Did these areas of the southern North Sea epitomise these types of environment more than the surrounding landscapes? Further work into the environmental signature of related deposits is needed to address issues such as this. The identification of refined seabed locations brings this possibility ever closer.

A final pattern relates to the near absence of carnivores within the assemblage. As they were top predators this is likely to be due to their general scarcity relative to herbivores. Whilst there are a few finds from the southern North Sea (*Canis lupus* [grey wolf] within British collections, therefore, as well as an *Ursus sp.* specimen and two Dutch *Homotherium* specimens [Reumers *et al.* 2003; Mol and Logchem 2009]) these are by no means prolific.

As ecological indicators these specimens still only give a coarse-grained idea of their environments, mostly, at this stage, as an addition to the chronological information. Future work within more refined locations, targeting specific deposits, will aim to strengthen this considerably. As another strand of chronological evidence, however, this coarse information supports the dominance of later Pleistocene, mammoth-steppe-adapted species.

6.2.3 Summary

The methods developed within this research have provided the means to use the most prolific resource from these landscapes. In combination with geophysical data it therefore allows us to focus our efforts on areas of higher potential and to appreciate the landscapes at increasing levels of detail.

The picture of the seabed presented by these specimens is clearly complex, with patches of deposit apparently representing a range of periods and environments. Whilst the specimens in the minority groupings are few, it is significant that we get these pictures from areas where, in terms of mapped Quaternary deposits, we would not expect them. Given the extrapolation that occurs for much of these deposit models between widely-spaced geophysical lines and only very occasional cores, this pattern is likely to be picking up on fragmentary seabed deposits of which we are currently unaware but which, once identified, can drastically alter our knowledge of these areas.

6.3 Implications for the bigger Palaeolithic picture

We have discussed the finer points that emerged from this research and how they apply to issues raised in Chapter Three. In this section the broader research questions that apply to the study will be addressed. These questions are central to the importance of research into Palaeolithic submerged landscape as they relate to the crux of the matter: what these areas mean for our understanding of hominins throughout the Palaeolithic, their behaviour, occupation patterns and capabilities. Three broad questions were raised in Chapter One:

- *With the potential for the existence of non-analogous environments, can we use the submerged material to redefine and further inform our current conceptions of the palaeoecological contexts of hominins throughout the Palaeolithic?*
- *Given that the pattern of occupation of Britain appears to be more sporadic than constant, can the inclusion of evidence from the southern North Sea aid our understanding of the patterning of hominin movements?*
- *Later Palaeolithic evidence shows that when marine resources are exploited they are exploited close to the shore. Are our preconceptions about a lack of early hominin coastal and marine adaptation and interactions therefore based on the invisibility of this record rather than its non-existence?*

Addressing these questions has the potential to redefine our interpretations of changes in hominin lifeways throughout the Palaeolithic. Identifying deposits, both archaeological and non-archaeological, will allow us to interpret the range of environments present in the southern North Sea and, possibly, those which are not known from any currently terrestrial sites. Furthermore, the discovery of archaeological traces would facilitate a greater understanding of the timing and nature of the movements of hominins in North West Europe. Through these archaeological traces the possibility of identifying exploitation within coastal/marine areas could raise interesting questions about how we currently perceive the use of alternative food sources. It is necessary to make it clear, however, that these questions remain presently unanswerable; their resolution still an ambitious task. The research presented here began from a point of knowing almost nothing about the submerged landscapes of the southern North Sea and so presents the first steps towards this. Through developing the foundations of an understanding of these landscapes it brings us closer to engaging with specific deposits and, therefore, to identifying and analysing deposits and artefacts. This is a significant step forwards in understanding the nature of both the ecological as well as archaeological signatures. Sites such as Area 240 and the Zeeland Ridges are examples of the fragmentary archaeological landscapes that we cannot simply engage with on a purely serendipitous basis but which require the more focused, bottom-up approach aimed at here.

Chapter Two of this thesis highlights the problems of assessing presence or absence of hominins throughout the Palaeolithic. With data resolution for archaeological signatures at such a mismatch to environmental proxies, and dating techniques either relative or with large margins of error, understanding the timing and nature of occupation for such a fragmentary terrestrial record is not easy. The problems that we will face when we have further evidence from the submerged zone will of course be no different, but increasing the amount of data available, as well as securing data that is likely to be ecologically different from that obtained from the currently terrestrial zone, should allow us to address these questions more broadly and more holistically. Evidence from the southern North Sea, being a swathe of landscape between a discontinuously-occupied and peripheral Britain and the northernmost extent of the more archaeologically-rich European continent, may hold the clues to the reasons for these discrepancies.

Sitting at the peripheries of Palaeolithic hominin occupation, the record from Britain can provide us with information about how hominins through time have engaged with marginal environments. For example, does the relatively high number of sites seen through MIS 11 relate to the preferences of *Homo heidelbergensis,* or early Neanderthals, or is this simply an artefact of the available evidence? Moreover, with this pattern of ephemerality or sporadic occupation continuing through the Middle and into the Upper Palaeolithic, is this a continued ecological preference or a pattern common to these hominins' changing exploitation behaviours? Although the answers are not provided here, there is great potential in the submerged zone for exploring these questions through a broader understanding of ecological niches and archaeological signatures.

We know from biostratigraphical data that, despite the initial MIS 12 breaching of the Weald-Artios ridge and the high interglacial sea levels of the succeeding interglacial, the British landmass remained a peninsula of Europe at least throughout the early stages of MIS 11. Probably a result of different seabed height and glacial isostatic adjustments, as well as the uncertain degree of ridge erosion, this meant that fauna, flora and hominins could continue to move across what is now the southern North Sea. Deposits, such as those of the Clacton Channel, demonstrate hominin occupation on the edge of the now submerged zone and imply that these occupation signals are likely to continue in deposits that are now offshore. This pattern of at least partial interglacial connection to the continent appears to continue until the Last Interglacial (MIS 5e [Preece and Meijer 1995]) and implies that a similar pattern of offshore deposits may be preserved for MIS 9 and 7 (e.g. Roe and Preece 2009; DONG 2011). After MIS 5e, the generally cooler environments of MIS 5d – 2 (the Weichselian) are likely to have provided periods of significantly lowered sea levels (Chappell *et al.* 1996; Siddall *et al.* 2003) with the emergent coastlines providing either tracts of near-coastal, habitable landscape, or landscape that stretched across to the continent. It is clear is that it is these lowered sea levels, regardless of the precise configuration of the resultant landmass, that have dominated throughout the Palaeolithic (Bailey and Flemming 2008).

Within these areas, then, what are we trying to get at? What do we expect from these ecologies that is so different from what we find in the terrestrial record? The most obvious answer is the potential for coastal and near-coastal environments: the environments for which we have little evidence throughout the Palaeolithic of north-western Europe (cf. Roberts and Parfitt 1998). These environments are significant for several reasons. They may contain evidence for exploitation of coastal resources as well as hominin occupation itself, and, beyond the archaeological record, they provide the opportunity to explore the dynamic ecologies of these coastlines. Understanding these ecologies moves us beyond the limits of the archaeological site to the wider landscape of occupation, allowing us to engage with hominin lifeways on a broader scale.

Studies of modern human marine resource exploitation have shown that marine resources are not transported great distances (<10km: Erlandson 2001; Bailey and Craighead 2003), which indicates that we are not likely to find evidence for marine exploitation at significant distances from the contemporary coastlines of the hominins in question. Given the submergence of these coastlines, this therefore presents a reasonable explanation why this evidence is currently missing. Furthermore, where large, archaeological shell middens are found, they are generally associated with shallow marine conditions, such as intertidal and lagoonal areas that support large numbers of shellfish. Given their shallow gradients, these are also areas that are rapidly affected by any rise in sea level and therefore either buried or eroded, which obscures and biases the archaeological picture (Bailey and Flemming 2008). The submerged zone plays a key role in the clarification of this apparently scarce Palaeolithic record.

An additional point relates to the nature of the wider environments in the now-submerged zone. It is important to remember that many of these landscapes were as far from coastal as some of our most landlocked counties are today. What is of potentially essential importance about these areas, then, aside from the basic fact of their being a large area of unexplored Palaeolithic landscape, is that they represent the lowland areas to what would then have been the uplands, now our modern landmass. When we think about the high potential areas for terrestrial Palaeolithic archaeology we think of lowlands and fluvial landscapes, whether this is entirely related to increased preservation in these areas or not. Given the confluences of several major fluvial systems and their tributaries across what is now the southern North Sea, it seems likely that these areas were attractive for hominins, both from the perspective of static resources, such as water, as well as for the targeting of prey species and, possibly, as corridors of movement through landscapes (Roebroek and Tuffreau 1999; Davies 2001).

In terms of archaeology within these fluvial corridors, Brown *et al.* (2013) have proposed some interesting ecological and taphonomic arguments for site distribution as a real phenomenon. With a large proportion (12/19) of British 'super-sites' (i.e. sites with >500 lithics) being located at tributary junctions where larger swathes of floodplain habitats existed, there is a strong bias towards these locations that prevails throughout the last four interglacial periods. Furthermore, the spatial patterning of finds being strongly concentrated in fluvial environments (relative to extensively field-walked interfluves in areas that never saw glaciation during the Pleistocene), has been argued to hold true for the Bose Basin, China, as well as pre-agricultural America. Ecological arguments have been proposed that these floodplain areas provide key nutrients from the plant and animal resources needed for development throughout all stages of life, including pregnancy and childhood, and fundamental to occupation of less productive latitudes (Brown and Basell 2013). This aquatic exploitation is interesting in its implications for the use of either coastal zones or areas of high fluvial confluence. Although Brown and Basell's research, based on existing site locations, indicates that coastal resources are probably not a primary source of nutrition, the persistent use of tributary junction environments may indicate that the southern North Sea basin, with its many fluvial confluences, was an attractive location for hominins and perhaps influenced movement or dispersal along these fluvial landscapes.

The lithic record also presents possible evidence of movement, with the potential for different technological groups occupying different areas of landscape. Ashton and Scott (*in press;* Scott *et al.* 2011) have suggested that both the typological and chronological aspects of the Levallois/handaxe record in Britain and north-western Europe throughout the Early Middle Palaeolithic (MIS 8-6) suggest patterns that relate to hominin movement and the use of the now-submerged zone. With the British sites apparently absent after mid MIS 7 but the north-west European sites from MIS 8-6 occupied far more regularly, this may have something to do with Britain's possible island status from this point onwards (Bates *et al.* 1998; 2000; 2003; 2010), coupled with inhospitable conditions throughout MIS 6 (presumably until the time of Lynford in MIS 3 when sea levels had dropped sufficiently to allow re-colonisation [Boismier *et al.* 2012]).

In discussing the potential avenues for new interpretation that the submerged landscapes may present we may risk presenting them as the answer to all our Palaeolithic questions. This is not what this research argues, regardless of how true or false that may turn out to be. With sporadic occupation patterns known from traditional archaeological landscapes on both sides of the southern North Sea (although generally more towards the continent), it is unlikely that the southern North Sea was a habitation hub. The available resources may have made it an attractive place to be, but it still existed at the edge of the (north-west European) Palaeolithic world. The important point is that these landscapes were present throughout the entire Palaeolithic and are totally unexplored: they are the relative lowland to our upland landscapes, the coastal zones and the interface between the continental record and the British.

Building a clearer picture of the distribution of extant Palaeolithic deposits in the southern North Sea, as discussed in the initial sections of this chapter, helps us to target specific areas so as to begin addressing these questions from both an archaeological and an ecological viewpoint. The timing of episodes of occupation within specific ecologies can help us to understand better the how and the why of our current patterns of occupation - and could see these patterns change.

6.4 **Conclusions**

Through investigating the patterning and distribution of the faunal resource from the southern North Sea, this research has allowed fresh insights into the nature and potential of an under-explored area of the Palaeolithic landscape. It has demonstrated the integrity of the deposits from which the specimens that we have considered derive and the possibilities, through understanding their recovery, for provenancing them on the seabed. This is a significant step forwards in our approaches to, and understanding of, the submerged Palaeolithic.

Appreciating their associated landscape formation has reinforced the observed patterning, with cold-stage – and therefore predominantly low-stand - species more prolific than those associated with higher sea levels. Recognising interglacial species in small numbers, however, demonstrates the existence of these general unmapped landscapes offshore (also supported by recent offshore projects [Dix and Sturt 2011]), and this further implies the complex organisation of fragmentary outcroppings of deposits and the need to understand them at a more local scale.

Chapter 7: Conclusions and Future Work

7.1 Conclusions

Understanding the submerged archaeology of the southern North Sea requires an understanding of the associated geology and seabed processes, but it is important that the archaeological questions remain our focus. Chapter One raised three overarching questions that research in this area has the potential to address: that of redefining palaeoecological adaptations, the timing and context of hominin movements, and the possibility for identifying marine exploitation. Despite the present capacity to answer these questions remaining frustratingly out of reach, the more focused questions which subsequently emerged have brought their elucidation significantly closer. These achievable questions focused on identifying, collating and analysing the existing resource from the southern North Sea in an attempt to do two things: first, identify what this can tell us about the nature of the specimens and their deposits. Secondly, determine what the distribution and patterning of these specimens can tell us about the submerged Palaeolithic record and how we can move this research forwards.

The geological history implies that a dominance of low-stand - and therefore generally cold-stage - deposits is the expected picture. This results from two main factors:

- Progressive subsidence of the North Sea basin meant that whilst interglacials immediately post-Elsterian (e.g. MIS 11) required only a small drop in sea levels to maintain a connection to the continent, the required drop grew increasingly large through time (Busschers et al. 2008; Ashton et al. 2011).
    - The proportion of warm stage to cold stage deposits would therefore have changed: towards the Late Pleistocene deposits forming in the southern North Sea basin would be increasingly from cold-stage

periods, including regressive phases at the ends of interglacials and transgressive phases at their beginnings.

- Those deposits subjected to the least amount of glacial, transgressive and regressive periods – and their associated effects – are also likely to be these later Pleistocene deposits which, furthermore, are less likely to be deeply buried than those from earlier periods.

So combining these two factors means that, although pre-Elsterian deposits should be present and potentially extensive, these are more likely to be buried beneath later Pleistocene deposits which have also undergone fewer potentially erosive phases. In addition, the later Pleistocene deposits that we would expect to find are those related to low-stand, cooler environment periods that prevailed throughout the Late Pleistocene.

Occasional fragmentary deposits from Early to early Middle Pleistocene, as well as immediately post-breach periods (e.g. MIS 11) of warm climate with a terrestrial connection should also be present, but their existence is largely inferred rather than demonstrated given the extrapolated nature of much offshore deposit mapping. In this case, then, the deposits in the near-shore areas, which – through differing trawling patterns – are at a higher resolution, are more likely to reveal such fragmentary, potentially interglacial, earlier deposits.

The results that emerged from the data in Chapter Four demonstrate the spatio-temporal nature of the resource, and are in agreement with this geological picture:

- Broad scale trends showing the dominance of post-Elsterian species, but which appear to lean towards the later end of this time-range (i.e. MIS 8 onwards)
    - Within this, the collections are dominated by species adapted to open, cooler environments such as those of late MIS 7 and MIS 3 such as *Mammuthus primigenius* (woolly mammoth) and *Coelodonta antiquitatis* (woolly rhino).
- Smaller scale trends from near-shore locations which show the existence of deposits of varied time periods:

- Deposits off the north East Anglian coast are dominated by pre-Elsterian species that most likely related to the CFbF / Yarmouth Roads Formation (related to the Oyster Bed and Sea Palling collections respectively), for example *Mammuthus meridionalis* (southern mammoth) and species of pre-Elsterian giant deer.
- Deposits off the south East Anglian/Essex coast (especially the Tendring Peninsula) are dominated by later Pleistocene, probably Late MIS 7 or MIS 3 species.
    - Smaller patterns of interglacial species such as *Palaeoloxodon antiquus* (straight tusked elephant) within the Tendring dataset also demonstrate the likelihood of outcropping fragments of these deposits.

Chapter Five looked at the smaller scale areas of the Oyster Bed, off Happisburgh, and the seabed off the Tendring Peninsula in more detail. High resolution swath bathymetry data collected for a refined location within the Wallet – identified using derived faunal material - demonstrated the preservation of what are interpreted as competent Quaternary deposit bedforms, distinct from other Tertiary- and Holocene–type bedforms in the vicinity. The correlation of the deposits identified using this geophysical data with the faunal specimens collated from this area shows significant progress in our approach to exploring the submerged Palaeolithic. Not only is this the first instance of a focused identification - defined entirely by derived fauna - of pre-LGM deposits offshore, but it highlights the potential of taking a proactive, reasoned approach to their location and investigation. The combination of this geophysical data with the observed faunal patterns increasingly implies that there are fragments of Pleistocene submerged deposits, potentially – at least in this area – associated with the margins of relict channel systems.

The importance of this research lies not so much in the details it provides but in the step-change in knowledge that it delivers for the offshore zone and the questions and opportunities that this raises. It has changed our understanding of the Palaeolithic of the southern North Sea from one dominated by abstract concepts of hominin occupation, punctuated by the occasional chance-find of a site, to a complex landscape characterised by fragmentary and multi-period deposits. This is an aspect of this area that was hitherto largely invisible, and highlights the emerging potential to begin engaging with these deposits in a more focused and targeted way.

Exploiting a unique and forgotten resource, this research provides both a broad and fine scale understanding of the archaeological picture of the southern North Sea. It will ultimately allow us to address Palaeolithic questions about the timing and nature of occupation that are otherwise heavily biased by the truncated terrestrial record. As a unique area of work that challenges our attitudes to the Palaeolithic record, its further development is essential.

7.2 Future Work

As the research presented here was the first study of this nature and scope, there is much work that can be done in the future to build-upon and investigate specific aspects of it. Furthermore, we have the opportunity at this stage to be very specific about targets for future work. These should look to advance the Palaeolithic investigation of the southern North Sea by addressing three essential questions:

- Further and more detailed chronological control of the collections, through species-level taxonomy
- The identification of human agency in the faunal record
- Site-specific interaction with the submerged deposits through geophysics, diving and sampling procedures.

The three main foci for this future work are proposed below:

1 – Age Range Determination and Environment Characterisation through Species Level Taxonomy

Of the existing specimens recovered from the southern North Sea, only a third have been identified to species level. The remainder are, to varying degrees, uncertain, and with an increasing number of modern collections being discovered it is crucial that this work is carried out. Understanding the evolution of taxonomic lineages has implications for the environments we recognise as well as date-ranges, as species evolve and become extinct in certain areas at certain times. Groups of fauna also imply climatic conditions, for example a cold stage fauna would typically include woolly mammoth and reindeer, whereas warmer conditions would be indicated by straight-tusked elephant and hippopotamus. Moreover, many of these groupings are specific to particular periods. Correct identification is thus absolutely crucial to furthering this research as it forms the backbone of the spatio-temporal patterning of the fauna telling us where these deposits are and the broad periods they date from. Robust and specific identifications must be acquired for as many of the specimens as possible.

Methods

Reference collections for Pleistocene fauna are not prolific, but several do exist. A good place to start would be the NHM, London, as well as the Naturalis Museum, Leiden, where a large comparative collection of Dutch trawled remains resides. Literature is also available for determining size and morphological features of specific species, but this is most beneficial when used alongside physical collections.

Identifying patterning in the distribution of these species, as well as any statistically significant links to seabed geology, could be carried out using Geostatisics in a GIS platform.

2 – Identifying human agency

Faunal remains allow us to ascertain ecologies and temporally specific environments which can be linked with hominin occupation, however, they do not give us the crucial evidence of this occupation. For the Palaeolithic, such activity is primarily identified in three ways: Stone tools, hominin fossils and cut-marked bones. Stone tools have been recovered by the offshore aggregate industry, but access to this potential resource is heavily restricted for health and safety reasons and the trawling industry is not recovering this type of material (due to net sizes). A Neanderthal fossil has been found off the Dutch coast (Hublin *et al.* 2009), but these are extremely rare in any context. However, increasing numbers of cut marked Pleistocene bones are being found washed onto beaches, demonstrating the potential of trawled specimens for adding this crucial aspect of occupation (Parfitt pers. comm.).

Surface marks on faunal specimens from the seabed indicate their post-depositional history, which can reflect conditions related to their terrestrial deposition as well as their subsequent submergence. Although important for recording a history of the bones, from an archaeological perspective distinguishing natural marks from any human signal is crucial. Looking to identify diagnostic, anthropogenic marks from tool use and processing is therefore a crucial aspect of any future work.

Methods

For the analysis of this material it will be necessary to involve the use of macro and micro techniques such as high resolution Microscopes, Reflectance Transformation Imaging as well as Scanning Electron Microscopes. This will enable a detailed assessment of the specimens, allowing potential cut marks to be analysed in an objective and quantifiable way.

Potentially, radiocarbon dating of appropriate specimens could be an option, strengthening species-related temporal patterns as well as occupation signals and tying deposits to specific date ranges.

3 – Resolving abstract concepts of submerged landscapes

Although most specimens identified so far have been from historic collections, Pleistocene bones are still being recovered from the southern North Sea. Frameworks have been set up to record this material, such as the British Marine Aggregate Producers Association protocol for archaeological recovery and the Fishing Industry Protocol for Archaeological Discoveries which is currently being piloted off the Sussex coast. These reflect a growing engagement with collectors over recent years, however, where they work well for much archaeology, for the Palaeolithic they are of limited use. Being reported via photograph, faunal elements are extremely difficult to identify and tool marks are impossible to recognise; a more targeted approach is required.

This doctoral research has already identified one area off the coast of Essex, with close to 300 bones from an individual trawler-man (Chapter Five). Having indicated where these specimens derive from, geophysical data collected across the study area demonstrated correlation of these faunal remains with a Pleistocene deposit on the seabed. The future potential of this work is clear and could be expanded upon by using the increased resolution offered by the initial foci of this future work to developed a site-specific aspect to this research. This potentially allows questions to do with the interaction between hominins and their ecologies at particular points in time and space to be addressed.

Where this approach differs, and which is a vital distinction for developing our attitude to the offshore zone, is that with specifically targeted areas this phase will be active rather than responsive. Furthermore, it will introduce a dissemination aspect to the programme, with outreach into specific trawling communities discussing the importance of understanding and reporting such finds for future research.

Methods

Further work on the historical specimens will define high potential areas within which to search for intact deposits. Through establishing relationships with current fishing communities in these identified locations, providing a much higher level of locational information, a series of investigative case studies based upon the specimens they are recovering could be developed. The potential for modern GPS-based recordings of the locations of the material and the integration of these with recent geophysical data would add exciting layers of increasing resolution to this picture. Tying-in with research on geological seabed deposits and outcroppings, this will in turn feed back into the temporal component.

Any new collections could be analysed using the techniques from points 1 and 2 resulting in a finer-grained map of the archaeological and ecological composition of particular seabed areas. Diver-based ground-truthing would be essential to fully investigate the identified areas, providing first-hand experience of the nature of the deposits, sampling and *in situ* artefact recovery.

The work presented in this thesis began from a situation where our engagement of the Palaeolithic of the southern North Sea was from a purely abstract perspective. Through a detailed assessment of the existing faunal resource and the development of methodologies for analysing their patterns and distributions, new insights have been gained about the nature of these landscapes. This is allowing us to begin appreciating the submerged Palaeolithic in a more tangible way than was previously possible, opening up exciting new avenues of research.

Chapter 8: Appendices

Please see attached CD for the raw faunal data (.xlsx)

Chapter 9: Bibliography

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