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Of mammoths and other monsters: historic approaches to the submerged Palaeolithic

Rachel Bynoe[1,*], Justin Dix[2] & Fraser Sturt[1]

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Recent research on the submerged central and southern North Sea basin has focused on the end of the story, the last few millennia before the final inundation. Much older deposits do survive, however, and are documented by collections of Pleistocene fauna recovered by fishing fleets operating from Dutch and British ports during the nineteenth and early twentieth centuries. Analysis of the British collections allows them to be assigned to specific areas of seabed and to broad stages of the Pleistocene climatic sequence. The results provide evidence of more complex and fragmentary undersea landscapes than can be detected using geophysical approaches alone, and indicate targeted areas for future work.

Keywords: North Sea, United Kingdom, Palaeolithic, submerged landscape, faunal analysis, museum collections

Introduction

Since Reid's seminal publication on submerged forests, a range of studies have attempted to define the archaeological potential of the North Sea (Reid 1913; Clark 1936; Wymer 1968; Coles 1998; Gaffney *et al.* 2007; Peeters *et al.* 2009). Much of this work, however, has understandably focused on the nature of the geological, and for the most-part Holocene, record. Investigation of archaeological remains has evolved at a far slower pace, particularly

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on the UK shelf. With data from UK waters we can, however, start to redress this balance by documenting the extant offshore faunal record which, over the last two centuries, has been dispersed across local and national collections, and by demonstrating its significance for key archaeological questions. While our research relates directly to the southern North Sea, and thus to the occupation of north-west Europe, this archival approach is applicable to any area of continental shelf that was exposed during the Quaternary.

Reid (1913: 2) noted that submerged deposits require focused attention, as their significance is likely to be overlooked by archaeologists. While submerged landscapes cannot hold the key to all of our unanswered questions, excluding them can only work to our detriment. In the case of the southern North Sea, much of the evidence from the lower reaches of Palaeolithic fluvial systems, argued to be important ecotones (Ashton & Lewis 2012), has been lost through submergence, along with strips of coastal deposits. If we do not engage with these invisible Palaeolithic landscapes we accept a serious bias to data distribution. New ways to access the existing submerged resource are therefore vital if we are to understand fully the scope of Palaeolithic occupation, movement and adaptation.

Large scale recovery of faunal material by Dutch trawlers since the 1960s (Kortenbout van der Sluijs 1970) has led to extensive investigation and characterisation of these assemblages from the most southerly sector of the southern North Sea (van Kolfschoten & Laban 1995; Mol *et al.* 2006; Mol & Post 2010), and strong relationships with their trawling industry have led to an ever-finer resolution of provenance. For the UK, the vast majority of material in museum collections was recovered during the nineteenth and early twentieth centuries. The subsequent decline of the trawling industry reduced the amount of material collected and curated, with a historical approach hence required in order to exploit the full potential of the resource. Significantly, this not only has the potential to help us understand distributions, but also to indicate where *in situ* sequences of deposits may survive.

This first quantification and analysis of the Pleistocene fauna from the UK sector of the southern North Sea demonstrates the degree to which the archaeological importance of this record has been under-valued. The provenance of the specimens can, to varying degrees, be correlated with particular areas of the seabed, crucially revealing significant chrono-spatial trends that can be used to target future work.

Archaeology and submerged landscapes

One hundred years after Reid, Roebroeks states: "Any consideration of the Pleistocene occupation history of [the North Sea] ... needs to deal with the fact that a major part of the landscape available to Pleistocene hunter-gatherers is currently submerged under the water" (Roebroeks 2014: 14). Despite this and other powerful statements there has been very limited archaeological investigation (Westley *et al.* 2013). Only two sites from UK waters—outside the inter-tidal zone—have been subject to detailed archaeological investigation: the Palaeolithic site of Area 240 (Tizzard *et al.* 2014) and the Mesolithic site of Bouldnor Cliff (Momber *et al.* 2011) (Figure 1). The general discourse that exists is one of noted high potential, but little recourse to the material record to demonstrate it.

Despite a lack of direct intervention or analysis of material recovered from UK waters, there has been a step change in our understanding of the offshore deposits and how

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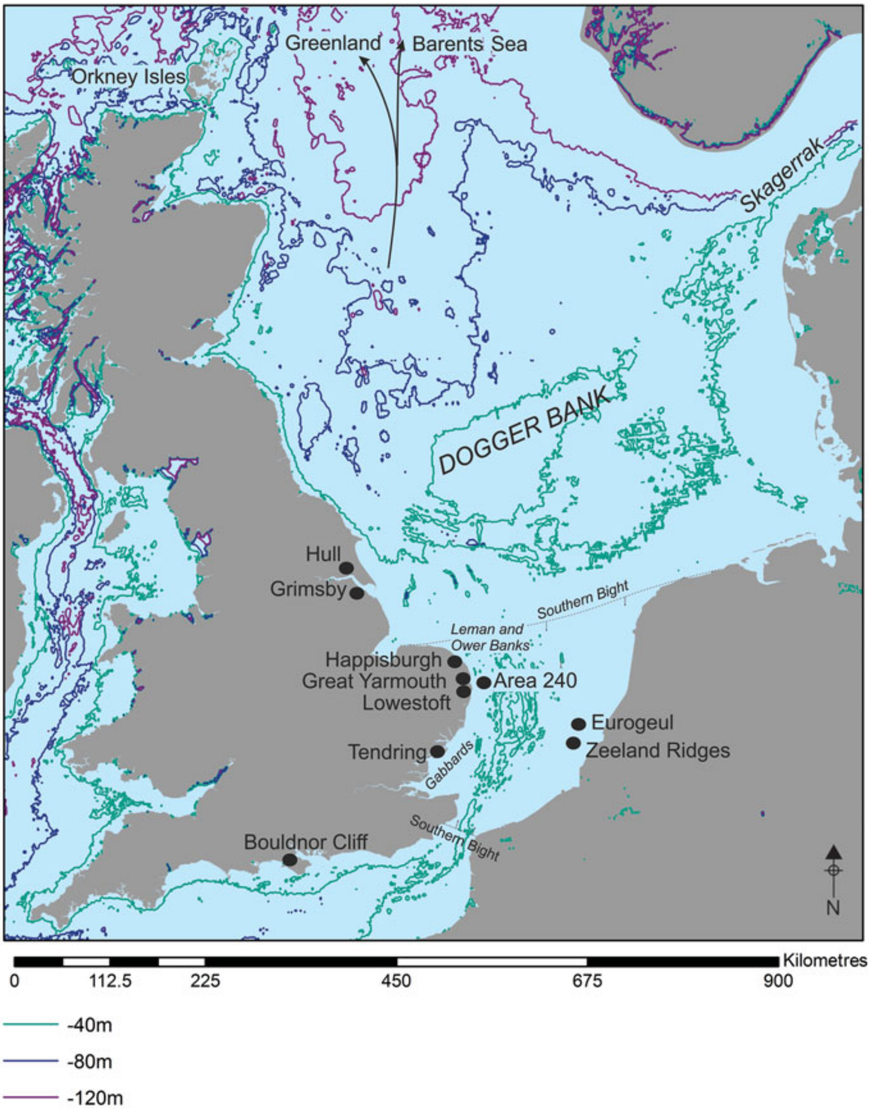

Figure 1. All locations and sites mentioned in the text, with contours showing current offshore bathymetry. Contours are derived from Smith and Sandwell (1997).

they relate to submerged landscapes. The pioneering work by Gaffney and his team on the Dogger Bank provided the first geophysical evidence of the preservation of large, postulated Mesolithic landscapes (23 000 km^2: Gaffney *et al.* 2009: 78). Subsequent exercises undertaken on large offshore industry datasets have started to expand our understanding of the geological complexity of the UK shelf, with fragmentary landscapes directly dated back to the early Middle Pleistocene (Dix & Sturt 2011). By contrast, the actual recovery of either archaeological or faunal material is limited to a few, poorly contextualised finds (Gaffney *et al.* 2009).

A different history of research is shown by the countries that share the waters surrounding the UK. Dutch researchers have examined large numbers of faunal remains, predominantly from the Brown Bank and the dredging of the Eurogeul (e.g. van Kolfschoten & Laban 1995; Mol *et al.* 2006). Radiocarbon dates place these largely in the Devensian-Weichselian, mammoth steppe environments (MIS 3/2, *c.* 60 000–15 000 years ago) (Mol *et al.* 2006; Mol & Post 2010). Even more significant was the discovery of the first offshore hominin fossil: a Neanderthal brow ridge, dredged from the Zeeland Ridges (Hublin *et al.* 2009). Geophysical and geotechnical interpretation of local deposits place this at *c.* 50 000–30 000 years ago (Hijma *et al.* 2012).

Remote sensing is extremely valuable for defining landscapes and deposits. Such projects are increasing in number with the public release of huge datasets from offshore infrastructure projects, but a corresponding push is needed to seek the material culture present on the seabed. The significance of serendipitous finds, such as Area 240, cannot be overstated, yet the fragmentary nature of outcropping Palaeolithic deposits demands a more proactive, focused approach if we are to continue to move the discipline forward.

Considerable steps have been made towards achieving the higher resolution understanding of offshore geological sequences required to contextualise archaeological finds. Investigations of the southern North Sea have progressed from broad-scale mapping of Pleistocene deposits (e.g. Cameron *et al.* 1992) to finer-grained analysis based on integration of multiple datasets (e.g. Dix & Sturt 2011; Hijma *et al.* 2012). This has increased the potential for the discovery of new finds within securely understood contexts. In order to move beyond broad generalisations, however, our understanding of the existing faunal and material cultural record in the UK sector must move to a commensurate level. Only then will we appreciate what the sequences of the southern North Sea can tell us about the Palaeolithic of the region, and thus how significant the identified deposits may be.

The record

Through the extensive work of antiquarians and amateur (and, to a limited extent, professional) archaeologists, a prolific body of faunal material, mainly from trawling, has been deposited within museum collections across the UK (Figure 2). These collections have never before been systematically investigated. Our work focused on national collections and those East Coast museums that were historically associated with major fishing fleets operating in the southern North Sea. Over 1120 specimens identified as being from the southern North Sea have been located, recorded and analysed (Bynoe 2014; see also online supplementary material (OSM)). These include 26 species previously identified by specialists at the Natural History Museum, Norwich Castle Museum and Colchester Museums Service, and a further 14 identified only to genus (Figure 3 and OSM).

Inevitably, taphonomic processes (visibility, collector preference and entrapment in nets) have skewed this record, favouring larger and more robust specimens. In order to maximise the interpretative potential of this record, the temporal distribution of each species was combined with information regarding where they were landed and the idiosyncrasies of the contemporary trawling industry. Such contextual information allows us to move beyond the find-spots shown in Figure 1 and to identify emerging patterns within the dataset.

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Museum / county service contacted	Number of finds
Aberdeen	0
Tyne and Wear	0
North Lincolnshire	0
Hull	0
Yorkshire (York)	0
East Riding, Yorkshire	0
Scarborough	0
Whitby	0
Lincolnshire	0
Hartlepool	0
Natural History Museum, Dublin	14
Norwich Castle Museum (housing finds from across the county)	263 (dominated by 19th century specimens)
Colchester Museums Service	342 (recently recovered)
Ipswich Museum	22
Southend-on-Sea	0
Natural History Museum, London (finds from across the country)	339 (dominated by 19th century specimens)
Kent	0
Portable Antiquities Scheme (PAS)	0
Historic Environment Record (HER)	Only BMAPA material from Area 240
British Marine Aggregate Producers Association (BMAPA)	139 (since 2005)

Figure 2. Locations of museum (and county) collections consulted, and sources with North Sea material, including total specimens.

Widespread use of trawling in the North Sea began in the nineteenth century and expanded rapidly, responding to demands greatly increased by the Industrial Revolution and population growth (Figure S1 in OSM; Butcher 1980; Robinson 1996; Engelhard 2008). Through understanding the development of this industry, crucial points can be identified that facilitate the broad provenancing of these specimens: first, those areas of the seabed exploited by trawlers and hence where the material might originate; and second, how the overall pattern—as well as the trawling ports the specimens were landed at—relates to the locations and activities of the antiquarians curating the material.

Published oral histories from trawlermen and historical sources indicate three main areas of seabed were exploited by trawling fleets (Figure 4; Butcher 1980, 1985; Robinson 1996):

- On and around the Dogger Bank, northwards towards the entrance to the Skagerrak and out towards the Shetland Islands/Greenland/Barents Sea; principally exploited by fleets operating from the north-eastern ports of Grimsby and Hull.
- On and around the Dogger Bank to the south of 55° but north of the Leman and Ower Banks; exploited by fleets working out of Great Yarmouth.
- Areas to the south of the Leman and Ower Banks in the north, to the Dutch coast in the east and as far south as the Gabbards; exploited by fleets working from Lowestoft.

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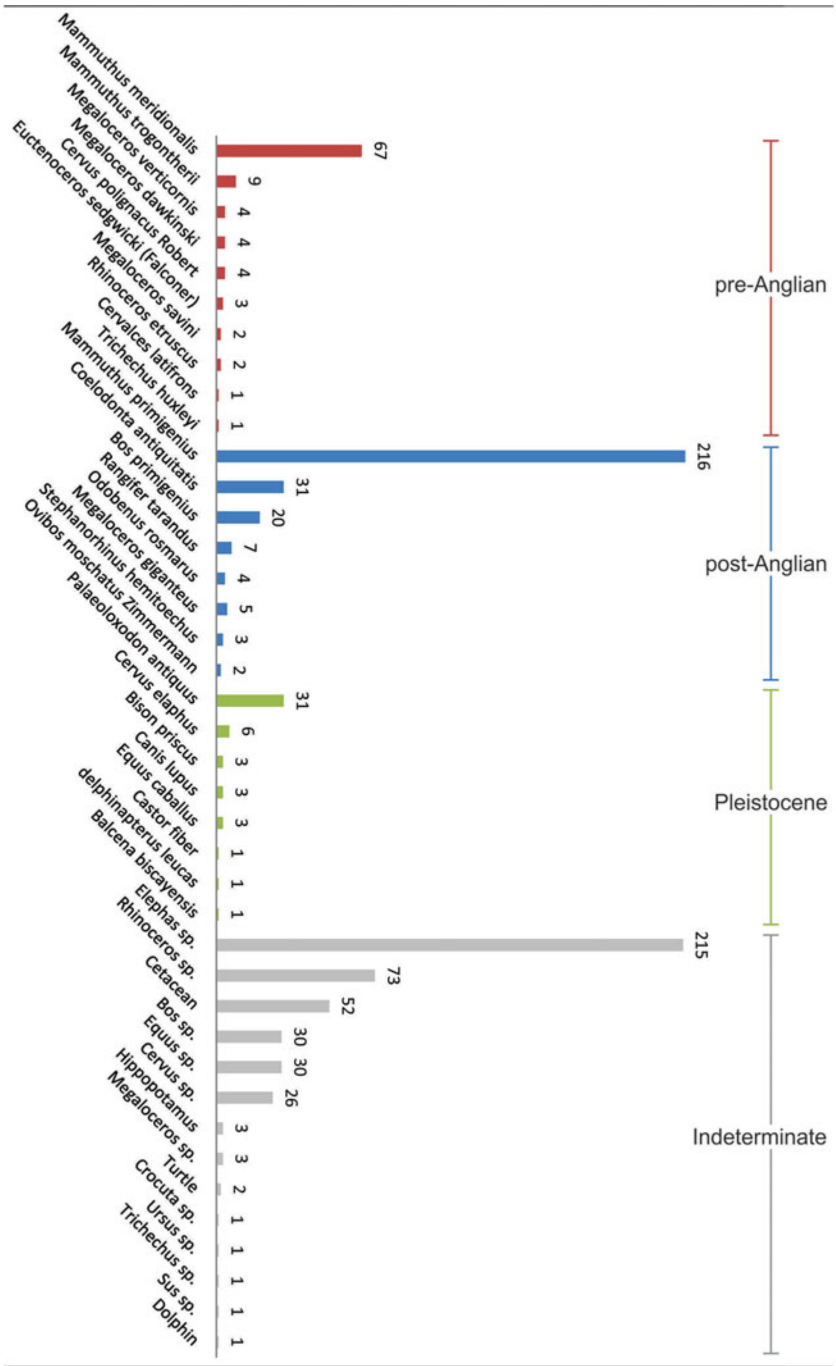

Figure 3. North Sea species from the UK data. Those in red are pre-Anglian, blue are post-Anglian, green denotes species present throughout the Pleistocene and grey shows fauna not identified to species level.

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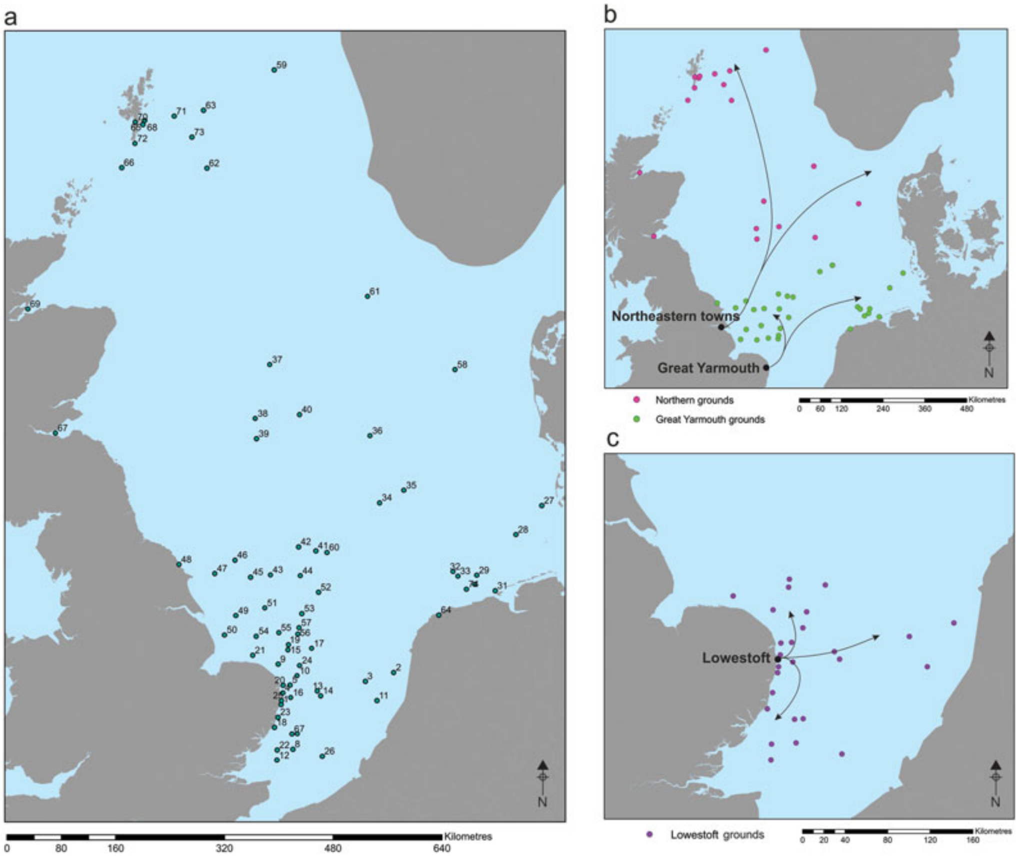

Figure 4. a) The range of historic trawling locations identified, see Table S2 in online supplementary material for corresponding numbers and co-ordinates; b) Great Yarmouth Grounds and Northern fleets; c) Lowestoft Grounds.

Trawling was also practised at a smaller scale by coastal communities (Smylie 1999; Butcher *pers. comm.*), providing a fourth element: smaller boats launched from the beach and exploiting areas within a few kilometres of the coastline, landing their catches at locations without formal ports.

We can therefore relate distinct fishing locations to specific ports (Figure 4 & OSM). Specimens landed at these ports can, in turn, be assigned to those areas of seabed.

Consideration must also be given to the antiquarian collectors who curated this material. Over 60 individuals were identified, but the bulk is attributable to four people: the Reverend James Layton, J.J. Colman, the Reverend John Gunn and John Owles. By noting where these collectors lived and where their specimens were landed (documented in acquisition registers and on original labels (Figure 5g), it is possible to link aspects of their collections with certain ports and, therefore, to areas of seabed (Figure 6).

Analysis

Of the 1120 specimens included in this study, 71% (n=790) have information that ties them to particular locations. Many are general areas such as the East Coast or Suffolk, but

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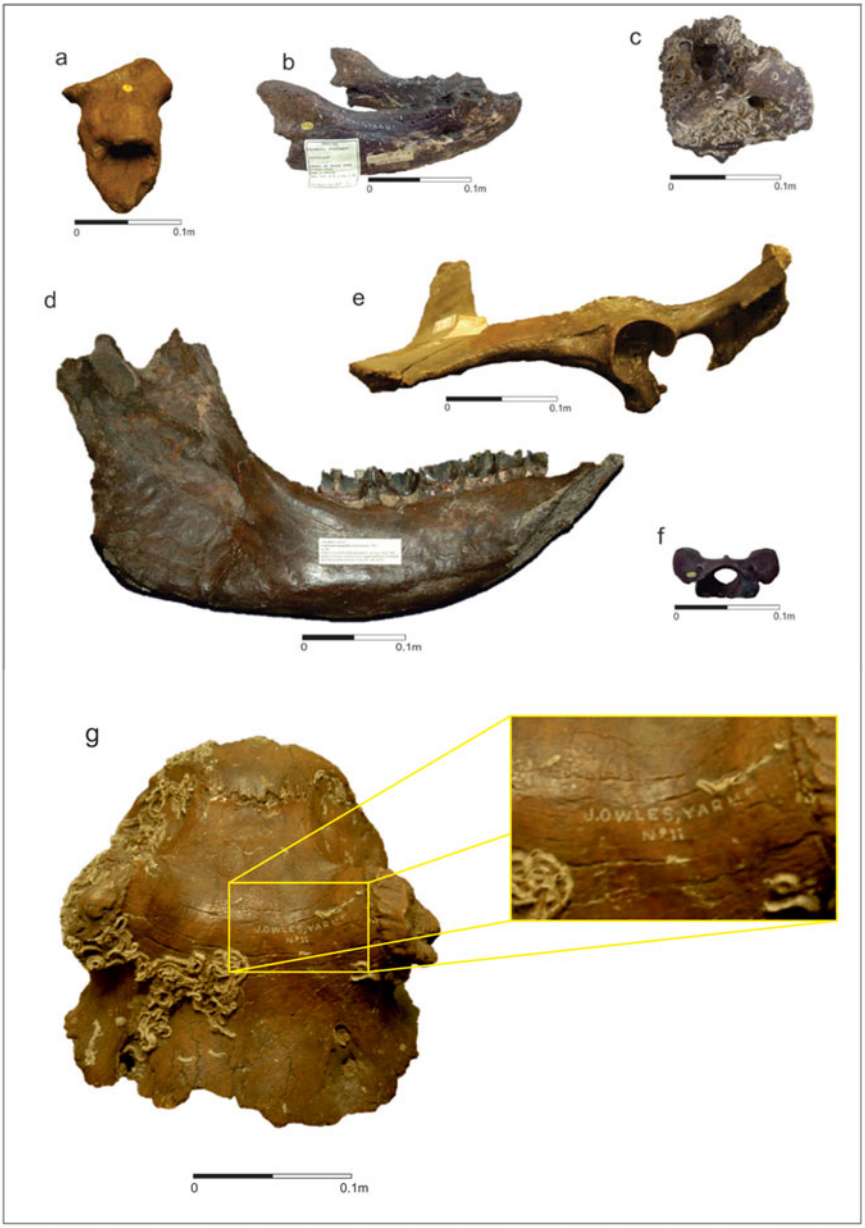

Figure 5. Examples of fauna from the UK collection with range of conditions: a) Cervus *sp. antler base, very rounded edges and breakage; b) mandible of* Trichechus huxleyi*, surface abrasion and marine growth; c) atlas of* Rhinoceros *sp., marine growth and extensive breakage; d)* Coelodonta antiquitatis *mandible, breakage of extremities but a well preserved bone surface; e) relatively well preserved pelvis of* Cervus *sp., breakage at the extremities; f) atlas of Canis lupus, well preserved bone surface and no breakage; g)* Cervus *sp. skull showing Owles' Great Yarmouth stamp.*

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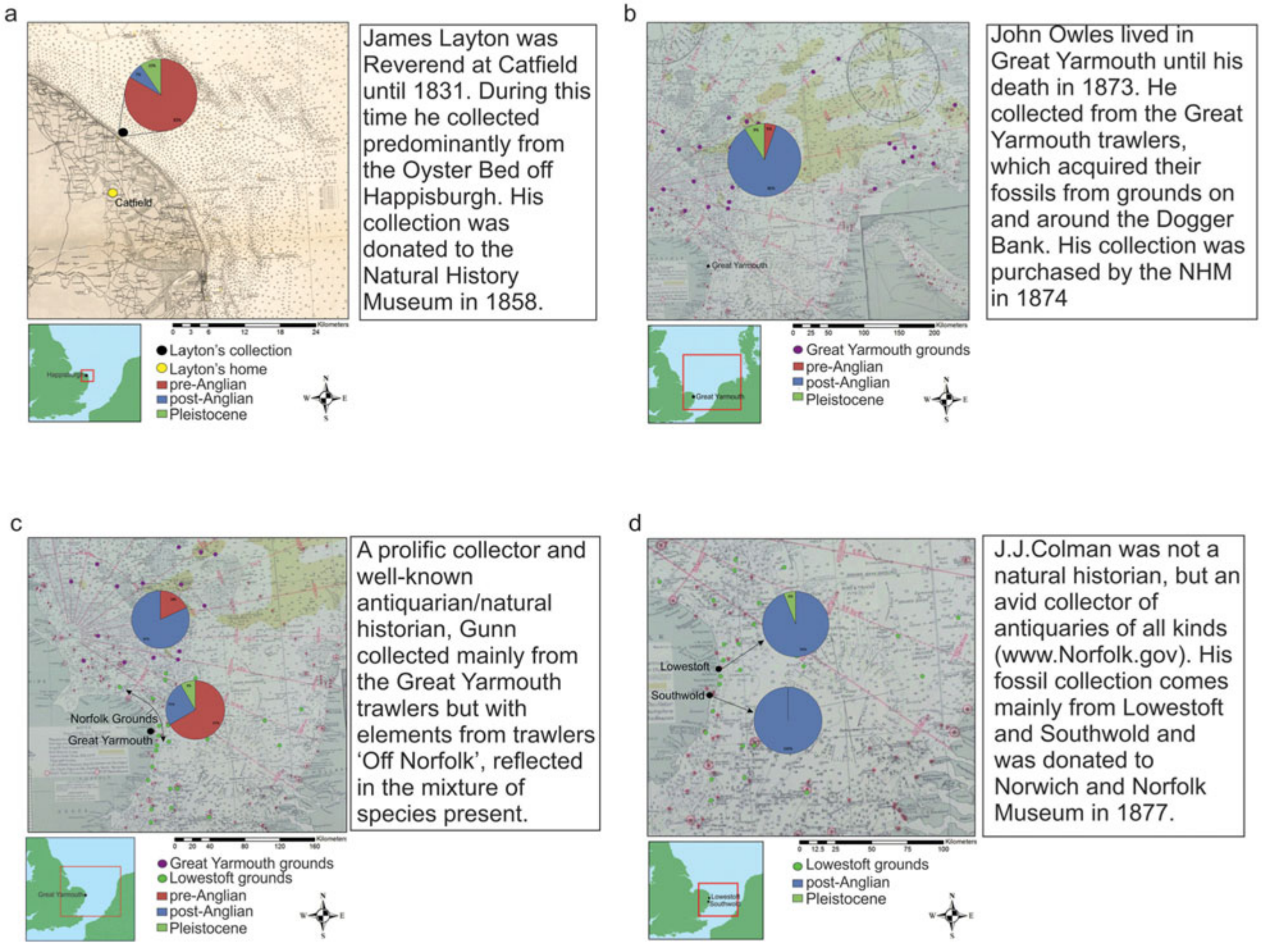

Figure 6. Collection areas of the main historic collectors: a) Layton; b) Owles; c) Gunn; d) Colman.

when combined with information regarding their collectors it is often possible to refine that further. For example, antiquarian John Owles collected from the Great Yarmouth fleets during the mid nineteenth century (Figures 5 & 6), so his 'East Coast' specimens can be associated with the grounds exploited by these trawlers. Similarly, those labelled as from Norfolk and Suffolk can be assigned to Lowestoft fishing grounds. The remaining 330 specimens lack locational information and are not included in the current analysis.

Recognising these spatial patterns allowed each set of specimens to be studied according to the area of the seabed from which they came. Within these spatial groupings, they were further refined by each species' occurrence pre- and post-Anglian Glaciation (478 000–424 000 years ago) in Britain (see Figure 7), providing broad spatio-temporal patterns. Chronological attribution is based on mammalian biostratigraphy, a commonly used tool for distinguishing particular stages of the Pleistocene, as the fluctuating climate of this period gave rise to rapid and geographically distinct species turnover (e.g. mammal assemblage zones (MAZ); Currant & Jacobi 2001; Schreve 2004 and references therein). This methodology can be applied at a high level of detail (i.e. assigning deposits to a particular MAZ or marine isotope stage). For our current, broad resolution analysis, however, it is used more simply to identify pre and post-Anglian species, in each case by combining groups of MAZs. The Anglian Glaciation has been taken as a marker point because of its significant effect on species turnover (Schreve 2004; Breda *et al.* 2010), so that temporal differences in the appearance and disappearance of the species represented should be easier to distinguish.

Clear patterns emerge from the analysis (Figure 8a). The Great Yarmouth specimens (Figures 4b & 8b) are dominated by post-Anglian species (85%) with only small numbers of pre-Anglian (9%), together with others that are present throughout the Pleistocene (6%), including small numbers of distinctly interglacial species, such as *Palaeoloxodon antiquus* (straight-tusked elephant). Of the post-Anglian species, 68% belong to *Mammuthus primigenius* (woolly mammoth), with far smaller percentages of *Coelodonta antiquitatis* (woolly rhino) and *Bos primigenius* (aurochs)—both 6%—as well as *Rangifer tarandus* (reindeer, 3%), with *Trichechus rosmarus* (walrus) and *Megaloceros giganteus* (giant deer) at <1% each.

The Lowestoft specimens (Figure 4c & 8b) are also dominated by post-Anglian species (72%), but with higher proportions of pre-Anglian (19%) and Pleistocene (9%) species, and, overall, a larger component of interglacial species. Again, this collection is dominated by *M. primigenius* (51%), but with slightly higher proportions of other post-Anglian species, such as *B. primigenius* (9%) and *C. antiquitatis* (8%). Both areas exhibit broad trends towards post-Anglian species, particularly those in existence toward the latter end of this time-range, dominated by species adapted to open, cooler environments such as those of late MIS 7 (243 000–190 000 years ago) and MIS 3 (60 000–30 000 years ago) (Currant & Jacobi 2001).

Finds from near-shore locations can also be linked to particular source areas, and reveal the presence of deposits from varied time periods. Sequences off the northern coast of East Anglia are dominated by pre-Anglian species (81% at Happisburgh). Here, a short-lived oyster bed in the 1820s yielded specimens collected by the Reverend Layton (Layton 1827), which account for 90% (n=44/49) of those from this area of seabed. Figure 8a shows the dominance of pre-Anglian species within this group, implying that this oyster bed was

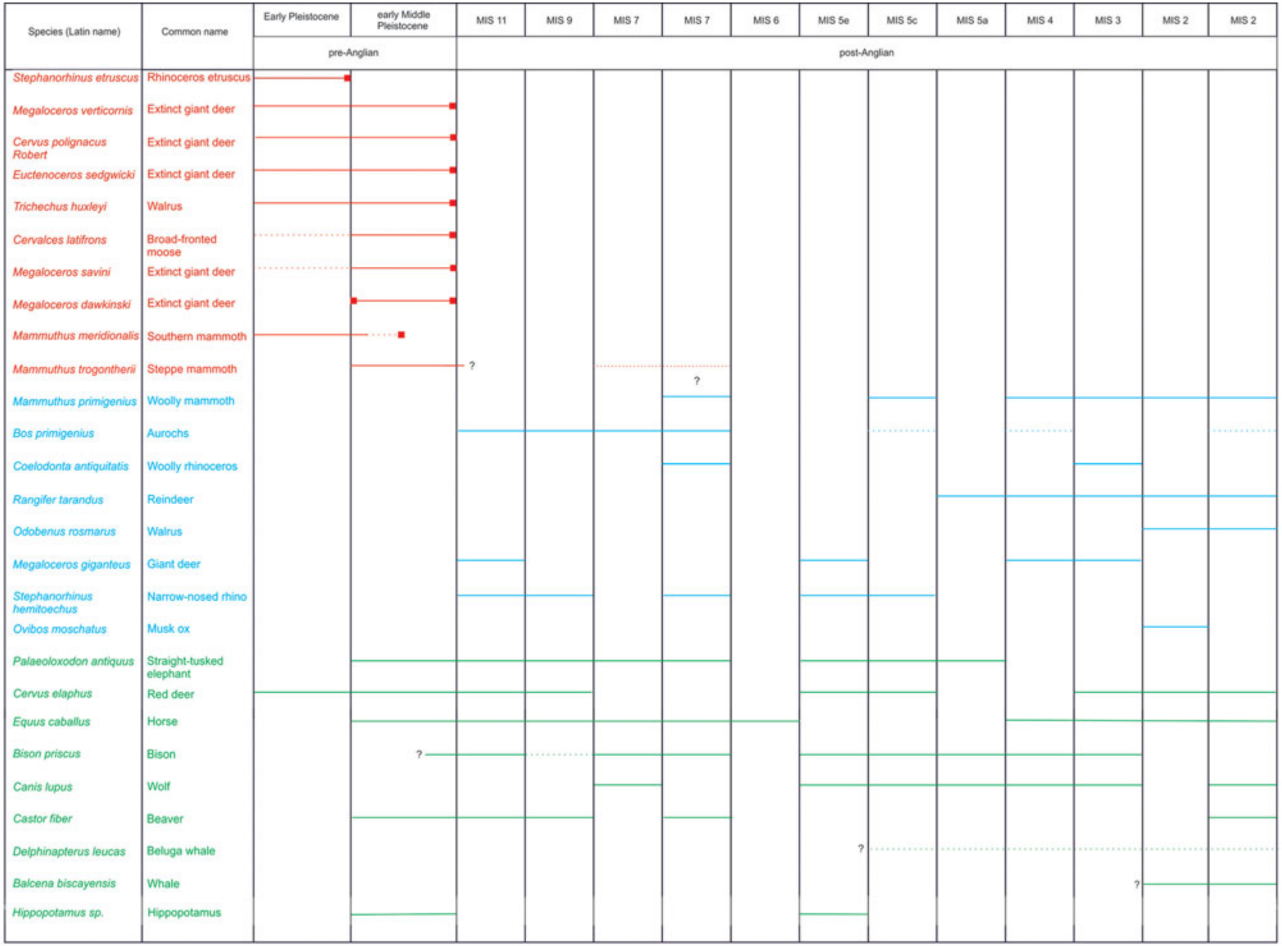

Figure 7. Faunal species recognised in the UK North Sea dataset, and their known occurrence in Britain (after Currant & Jacobi 2001; Schreve 2004; Breda et al. *2010; Lister* et al. *2010; Preece & Parfitt 2012). Red squares indicate the known first and last appearance dates of species.*

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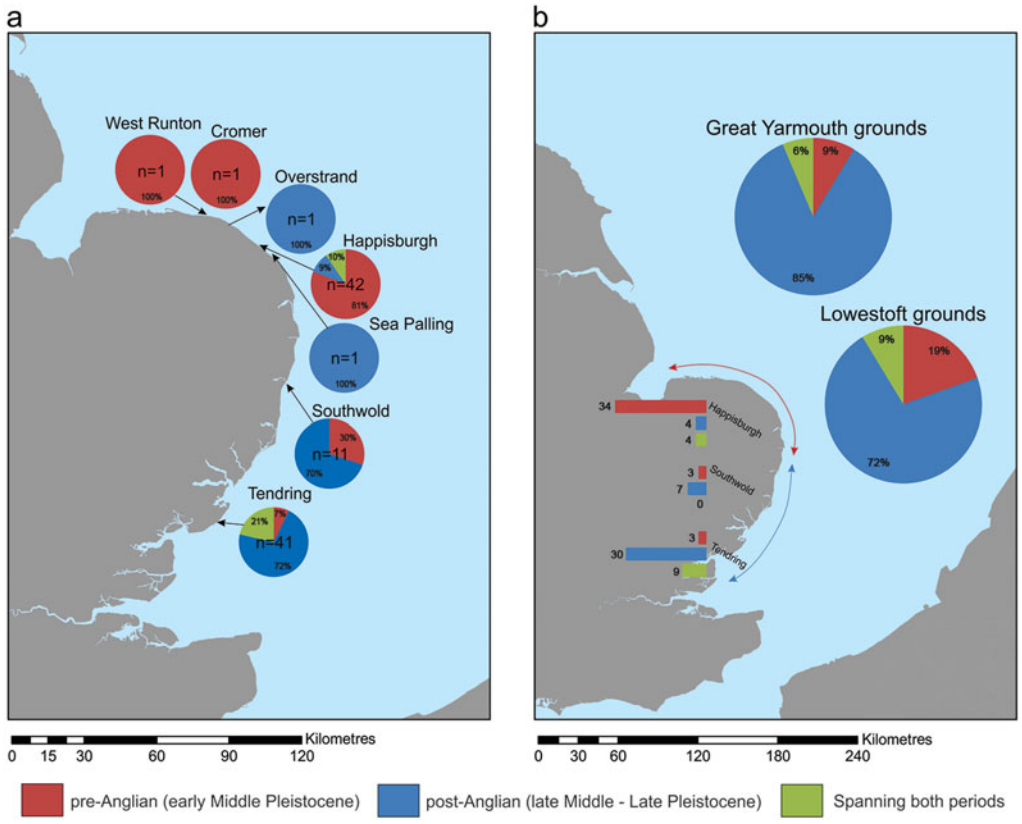

Figure 8. a) Changing proportions along the coastal locations; b) changing proportions from Great Yarmouth and Lowestoft fleets, plus inset chart showing the coastal species from locations with larger sample sizes.

sited upon submerged fossiliferous deposits of the Cromer Forest-bed Formation. Surviving accounts of the oyster bed place its exact location at "[a]bout three quarters of a mile from shore, opposite Happisburgh" (Reid 1890: 174), with a hint of its existence on an 1826 map showing a seabed obstruction at that position (Figure 9). This suggests a relatively discrete area of seabed that is currently under investigation.

Near-shore deposits towards the south (Figure 8a: especially the Tendring Peninsula) are dominated by later Pleistocene species (n=75%), probably Late MIS 7 or MIS 3 from the dominance of *M. primigenius* and *C. antiquitatis* (Currant & Jacobi 2001). Using locational information from a local trawlerman in combination with geophysical data, these 'Tendring' specimens suggest the existence of a discrete area of fossiliferous deposits for further investigation. In addition, smaller numbers of interglacial species, such as *P. antiquus*, *Hippopotamus* sp. and *Stephanorhinus hemitoechus* (narrow-nosed rhinoceros), within the Tendring dataset, demonstrate the likelihood of outcropping Last Interglacial deposits, supported by an OSL date of 116±6.5 ka from a sediment core taken from associated deposits (Dix & Sturt 2011: 110).

In these two examples, the observed patterns demonstrate that the search for submerged Palaeolithic deposits could be narrowed to specific locations. There are also differences of scale. Higher-resolution information provides local insights into hominin behaviour or ecologies, while broader evidence addresses longer-term patterning of environmental and archaeological change.

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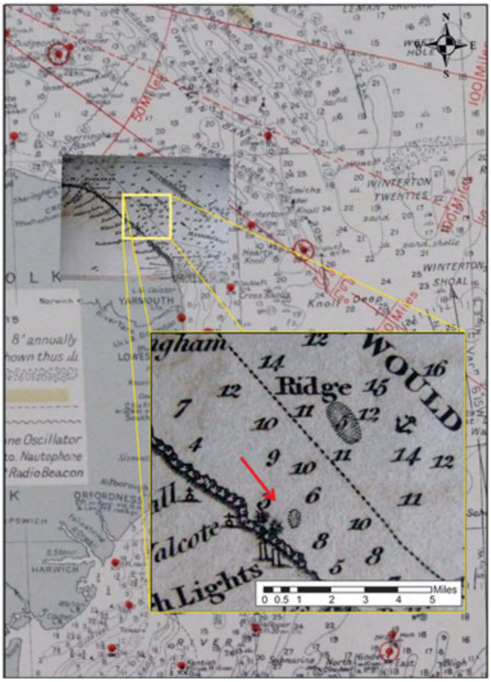

Figure 9. Imray, Laurie, Norie & Wilson fishing chart from 1964 with expanded box of an 1826 chart showing the presence of an area of seabed obstruction in the location of the described oyster beds.

Discussion

In the collection as a whole there is a dominance of post-Anglian fauna, with *M. primigenius* by far the best represented species (Figure 3). This may be due to biases of size, robusticity or visibility, but is reinforced by relatively high numbers of other post-Anglian species. These have probably been subject to fewer episodes of glacially related erosion owing to their more recent deposition, and are less deeply buried. This is supported by recent geophysical work on the Dogger Bank, which indicates that large areas of Early Holocene deposits, sometimes only 1m thick (Fitch *et al.* 2005), overlie those from the Late Pleistocene (Gaffney *et al.* 2007, 2009). Given the wide geophysical line spacing and necessary extrapolation for the creation of these deposit models, it is possible that outcropping deposits yielding these specimens are being missed by these analyses.

Within this broad post-Anglian group there is scope for further refinement, as several species appear at different points, forming part of a common assemblage type. Eight species are post-Anglian (Figure 3), all of which (aside from *B. primigenius* and *S. hemitoechus*) could be associated with mammoth steppe (Guthrie 1982, 2001; Kahlke 1999; Currant & Jacobi 2001), and with the periglacial environments that prevailed in the southern North Sea throughout the Late Pleistocene (e.g. Mol *et al.* 2006; Mol & Post 2010). These eight species are similar to van Kolfschoten and Laban's (1995) third faunal group from the Dutch North Sea, 'Late Pleistocene terrestrial'. Some of these species (*C. antiquitatis*, *M. primigenius*) have, however, also been found within coombe rock deposits of MIS 8 age (*c.* 300 000–244 000 years ago) in the Ebbsfleet Valley (Bridgland 1994), making their association with the Late Pleistocene less conclusive, but nevertheless placing them within the broad period of mammoth steppe environments.

Despite the dominance of younger species, the relatively high frequency of pre-Anglian fauna (22%, n=97) also demonstrates the survival of much older material, a picture also seen in the Dutch groups ('Late Early Pleistocene/early Middle Pleistocene terrestrial': van Kolfschoten & Laban 1995). The deeper burial of deposits from these earlier periods, however, means that their potential for outcropping is reduced but, with more detailed mapping, their potential locations can be refined. All of the species (other than the Early Pleistocene *S. etruscus*) belong within the early Middle Pleistocene.

The heavily trawled Brown Bank (historically exploited by Lowestoft trawlers during the summer) and the Eurogeul are dominated by Late Pleistocene mammoth steppe material (Mol *et al.* 2006; Mol & Post 2010). In the same vicinity, Dutch trawlers throughout the 1960s and 1980s were recovering large quantities of fauna dominated by early Middle and Late Pleistocene species, with only a few Early Pleistocene species—*M. meridionalis* and *Anancus arvernensis*—both early forms of mammoth so far not seen in the UK data (van Kolfschoten & Laban 1995).

As they were collected from approximately the same areas of seabed, the UK specimens from off Lowestoft show similarities when compared with the specimens from van Kolfschoten and Laban (1995): a dominance of *M. primigenius* and other Late Pleistocene species, and good representation of pre-Anglian species (Table 1). The greater diversity of species in the Dutch data probably reflects the history of the UK collections, which contain many of the same mammals at genus level that are not yet identified to species. The higher numbers of early Middle Pleistocene species within the UK data could result from the exploitation of seabed outcrops close to the East Anglian coastline, recovering species associated with the Cromer Forest-bed Formation.

This species patterning may be due to the presence of Pleistocene outcrops underneath (and between) mobile sand banks in the southern North Sea. This raises the issue of sediment accumulation and movement both burying and exposing relevant deposits on the seafloor; future work may be key to identifying the location of these deposits.

Ongoing work in the Dutch sector—drawing on relationships with modern trawlers to improve spatial resolution—supports the inference from the UK data that areas of intact Pleistocene deposits survive in the southern North Sea. Further direct investigation of these deposits and their archaeological potential is now crucial.

The Quaternary geological record of the southern North Sea forms an important part of this research. Understanding the nature of its formation and the processes that have affected, and continue to affect, the deposits will be key to refining our knowledge of both faunal and archaeological assemblages. This area of research is not, however, within the scope of this paper; for reviews on the geology of the area see Cohen *et al.* (2014 and references therein).

Ecological patterning

Taxonomic evolution has been used throughout this analysis to provide a broad chronological framework for the groups of specimens (see Figure 7). The current level of research into submerged Palaeolithic landscapes does not, however, permit us to appreciate the finer aspects of dynamic ecologies; that should form a vital aspect of future, more targeted work. Today, we have a coarse picture derived from large-bodied, mainly herbivorous mammals that fall into the categories of either cold-stage or warm-stage fauna, with the former dominating.

Research

Table 1. Species list of all UK fauna, showing how the Lowestoft data compare with the spatially comparable Brown Bank data (van Kolfschoten & Laban 1995).

Species	Dutch data	Lowestoft data only	All UK data
Proboscidea			
Mammuthus meridionalis – southern mammoth	x	x	x
Mammuthus trogontherii – steppe mammoth	x	x	x
Mammuthus primigenius – woolly mammoth	x	x	x
Palaeoloxodon antiquus – straight-tusked elephant	x	x	x
Elephas sp. – elephant/mammoth	x	x	x
Artiodactyla			
Bison priscus – bison	x	x	x
Bos primigenius – aurochs	x	x	x
Hippopotamus sp. – hippopotamus	x		x
Ovibos moschatus Zimmermann – musk ox	x	x	x
Cervus elaphus – red deer	x	x	x
Capreolus capreolus – roe deer	x		
Megaloceros verticornis – giant deer		x	x
Megaloceros dawkinski – giant deer		x	x
Cervus polignacus Robert – giant deer		x	x
Euctenoceros sedgwicki (Falconer) – giant deer		x	x
Megaloceros savini – giant deer		x	x
Rangifer tarandus – reindeer	x	x	x
Megaloceros giganteus – giant deer		x	x
Alces alces – moose	x		
Cervalces latifrons – broad-fronted moose	x		x
Sus scrofa – wild boar	x		x
Cervus sp. – deer	x	x	x
Megaloceros sp. – giant deer	x	x	x
Bos sp. – aurochs	x	x	x
Perissodactyla			
Equus caballus – horse	x	x	x
Equus bressanus – horse	x		
Equus hydruntinus – horse	x		
Stephanorhinus hemitoechus – narrow-nosed rhinoceros		x	x
Coelodonta antiquitatis – woolly rhinoceros	x	x	x
Rhinoceros etruscus – rhinoceros etruscus	x		x
Rhinoceros sp. – rhinoceros	x	x	x
Equus sp. – horse	x	x	x
Carnivora			
Canis lupus – wolf	x	x	x
Crocuta sp. – hyaena	x		x
Panthera leo – lion	x		
Ursus arctos – brown bear	x		?
Ursus speleus – cave bear	x		?
Lutra lutra – Eurasian otter	x		
Carnivora – Pinnipedia			
Obodenidae			
Trichechus huxleyi – walrus			x

Table 1. Continued.

Species	Dutch data	Lowestoft data only	All UK data
Obodenus rosmarus – walrus			x
Cetacea			
Cetacean – whale		x	x
Cetacea – Odontoceti			
Dolphin – dolphin		x	x
Monodontidae			
Delphinapterus leucas – beluga whale			x
Cetacea – Mysticeti			
Balaenidae			
Balcena biscayensis (Eubalaena glacialis) – North Atlantic right whale			x
Rodentia			
Castor fiber – European beaver	x	x	x

The relatively low numbers of *P. antiquus* specimens, despite their broad temporal range and large, robust bones, suggests that interglacial deposits are poorly represented. This is supported by the relatively small proportions of other representative interglacial species such as *Castor fiber* (European beaver), whose presence indicates riparian, woodland habitats, and *S. hemitoechus*. Higher sea levels during interglacials may have been responsible for the relative paucity of interglacial deposits on the seabed.

The prevalence of *M. primigenius* is also significant from an ecological perspective. *M. primigenius*, alongside *C. antiquitatis*, is present during the interglacial of MIS 7 (Figure 7) where it is associated with a temperate climate, but open environments (Candy & Schreve 2007). Its dominance in this analysis is, therefore, not necessarily indicative of glacial conditions, but of the expansion of the open, mammoth steppe from MIS 8 onwards.

One unusual feature that has been noted here and elsewhere (Mol *et al.* 2006) is the abundance of *C. antiquitatis* from the southern North Sea. This species is relatively common, given its restricted temporal range, especially within the tightly confined Tendring dataset. Here there is also a high proportion of *Rhinoceros* sp. remains (unidentified to species level). It will be interesting to see if these specimens ultimately fall into the *C. antiquitatis* category.

The high frequency of *C. antiquitatis* within two southern North Sea datasets may indicate that there was something particular about the habitats in these areas that *C. antiquitatis* found preferable, but that is as yet unknown. They were a grazing species adapted to seasonal variability (Kahlke & Lacombat 2008), exploiting open grasslands as well as glacial tundra steppe, e.g. Ariendorf 1 (Turner 1997), and were most prolific throughout MIS 3 (Kahlke & Lacombat 2008). Did certain habitats that existed in what is now the southern North Sea epitomise these types of environment more than the surrounding landscapes? Further work on the environmental signature of deposits related to the faunal specimens is needed to address issues such as this, and will become easier once specific seabed locations have been identified. As ecological indicators, these individual specimens offer only a coarse-grained indication of their environments. As another strand of chronological evidence, however, the prevalence of *C. antiquitatis* supports the dominance of later Pleistocene, mammoth steppe-adapted species.

The picture of the seabed presented by these specimens is complex, with patches of deposits representing a range of periods and environments. The sporadic occurrences of interglacial species are significant, as the broad-scale mapping of Quaternary deposits would not lead us to expect them. Given that large-scale deposit models rely on widely spaced geophysical lines, with only occasional cores for groundtruthing, this pattern is likely to be picking up on small fragments of seabed deposits that are currently being missed.

Conclusions

This research has demonstrated that before embarking on expensive and time-intensive archaeological investigations of the seabed, it is possible to establish the broad record of the offshore zone through engagement with extant museum collections. Historical research in tandem with conventional faunal identification not only releases an extensive (>1100 specimens) and hitherto largely unacknowledged resource, but enables a broad spatially and temporally constrained record to be constructed. While currently working at a relatively coarse resolution in terms of biostratigraphical analysis, even at this coarse level, patterns are emerging: the dominance of cold-stage, post-Anglian species reflects the more recent formation of these deposits, yet the signals of warm-stage species, both pre- and post-Anglian in date, provides hints of a complex and fragmentary landscape often missed by geophysical approaches alone. The identification of several refined seabed locations demonstrates the potential of this method to locate these fragments, with ongoing work looking to directly investigate the deposits through groundtruthing by divers. Analysis of recovered specimens for anthropogenic evidence, such as cut marks, will then be used to bring the archaeological picture into greater focus.

As this study has shown, there can be no doubt about the enormous potential of the offshore archaeological record for Palaeolithic research.

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Supplementary material

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