

# Coastal curios? An analysis of *ex situ* beach finds for mapping new Palaeolithic sites at Happisburgh, UK

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**ABSTRACT:** Recent archaeological discoveries from exposures of the Cromer Forest-bed Formation at Happisburgh, UK, have radically changed interpretations of the nature and timing of early hominin occupation of northern latitudes, but this *in situ* archaeology is only one part of the picture. Surface finds of Pleistocene mammalian remains have been found along this coastline for centuries, with stone tools adding to this record over the past 7 years. The *ex situ* nature of these finds, however, means they are often seen as limited in the information they can provide. This work contributes to a growing body of research from a range of landscape and environmental contexts that seeks to demonstrate the value and importance of these *ex situ* assemblages. Here the focus is on Palaeolithic flint artefacts and Pleistocene mammalian remains recovered by a group of local collectors through systematic, GPS-recorded beach collection from 2013 to 2017, and their use in developing a methodology for working with *ex situ* Palaeolithic finds in coastal locations. The results demonstrate significant patterning that identifies unexplored exposures both onshore and offshore, considerably expanding the known extent of deposits and facilitating new insights into the wider archaeological landscape associated with the earliest occupation of northern Europe.

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**KEYWORDS:** *ex situ*; Happisburgh; Palaeolithic archaeology; Pleistocene

## Introduction

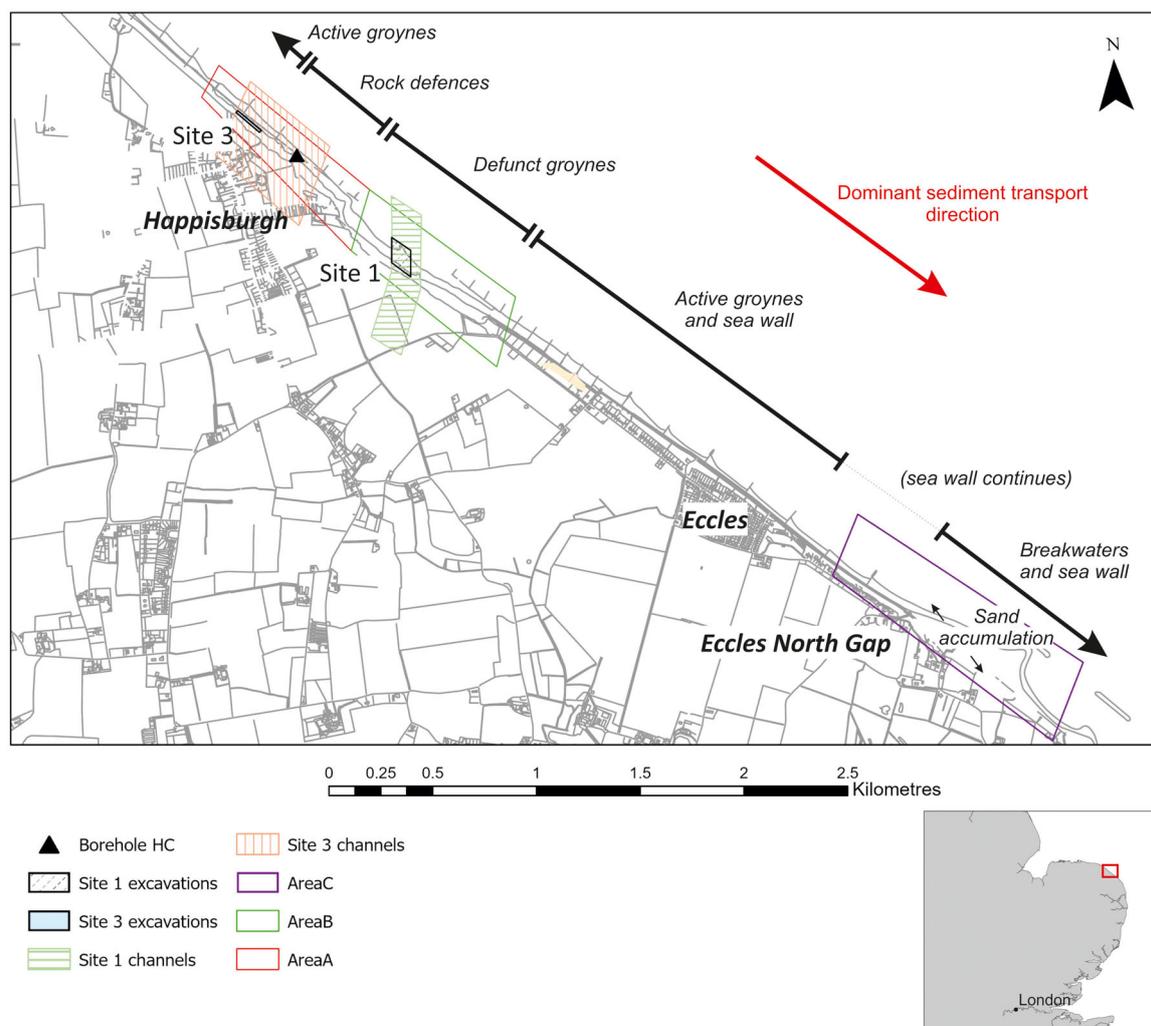
The Pleistocene archaeological record is inherently complex, filtered not only by initial behaviours of creation and discard, but also by post-depositional and taphonomic processes. The resulting archaeology is invariably fragmentary, dispersed and, for the most part, disturbed from its original context; the *in situ* 'site' forms a minute proportion of the available record (Foley, 1981). Alongside this is the compounding factor that hominins lived within landscapes, not just discrete 'sites', with the extent and use of these landscapes unlikely to have been fixed in space or time but fluid and relating to both dynamic environmental and social variables (Foley and Kilmurry, 1980; Foley, 1981; Isaac, 1981). Whilst challenging, the interpretation of the resulting archaeologically recorded 'scatters' in these landscape can offer insights into wider land-use strategies (e.g. Steinberg, 1996; Bailey, 2007; Holdaway and Fanning, 2008; Stern, 1993). The scale of these investigations needs to reflect these differing archaeological signatures, from the high-resolution and short-lived but high-density sites such as Boxgrove, to those made up of palimpsests, dispersed or mixed aggregations of artefacts at a range of potential scales (e.g. Stern *et al.*, 1993, 1994; Hosfield *et al.*, 2007; Hardaker, 2011; Davies and Holdaway, 2018). This relates to long-asked

questions of how to effectively 'tack' between these different scales of information (e.g. Wylie, 1989; Gamble, 1986) and highlights the need for creativity in locating, excavating and interpreting the record; interpretations are limited by the scale of investigations (e.g. O'Connell 1987; Conneler *et al.*, 2012).

In this paper, the interpretations derive from an analysis of the distribution and condition of 741 Palaeolithic flint artefacts and 157 mammalian fossils recovered from modern beach sediments at Happisburgh, UK (Fig. 1). The coastline at Happisburgh contains Early and early Middle Pleistocene deposits of the Cromer Forest-bed Formation (CF-bF), which exist underneath cliffs, predominantly composed of Anglian till [Marine Isotope Stage (MIS) 12, c. 0.47 Ma], and are episodically exposed on the foreshore. The key archaeological sites of Happisburgh Site 1 and Site 3, with its associated footprint horizon, are also present (Fig. 1; Parfitt *et al.*, 2010; Ashton *et al.*, 2014; Lewis *et al.*, 2019). Investigating the CF-bF, however, is complicated by the effects of fluctuating Quaternary sea-levels and regional tectonic movements. These processes have led to the submergence, fragmentation, burial and erosion of formerly terrestrial components of these landscapes, which once comprised low-lying plains dissected by large, resource-rich river systems and dry land that connected Britain to the European continent (Fig. 2; Cameron *et al.*, 1992; Hijma *et al.*, 2012). The submergence of these landscapes has significantly reduced the ease of accessing and studying these early occupation events.

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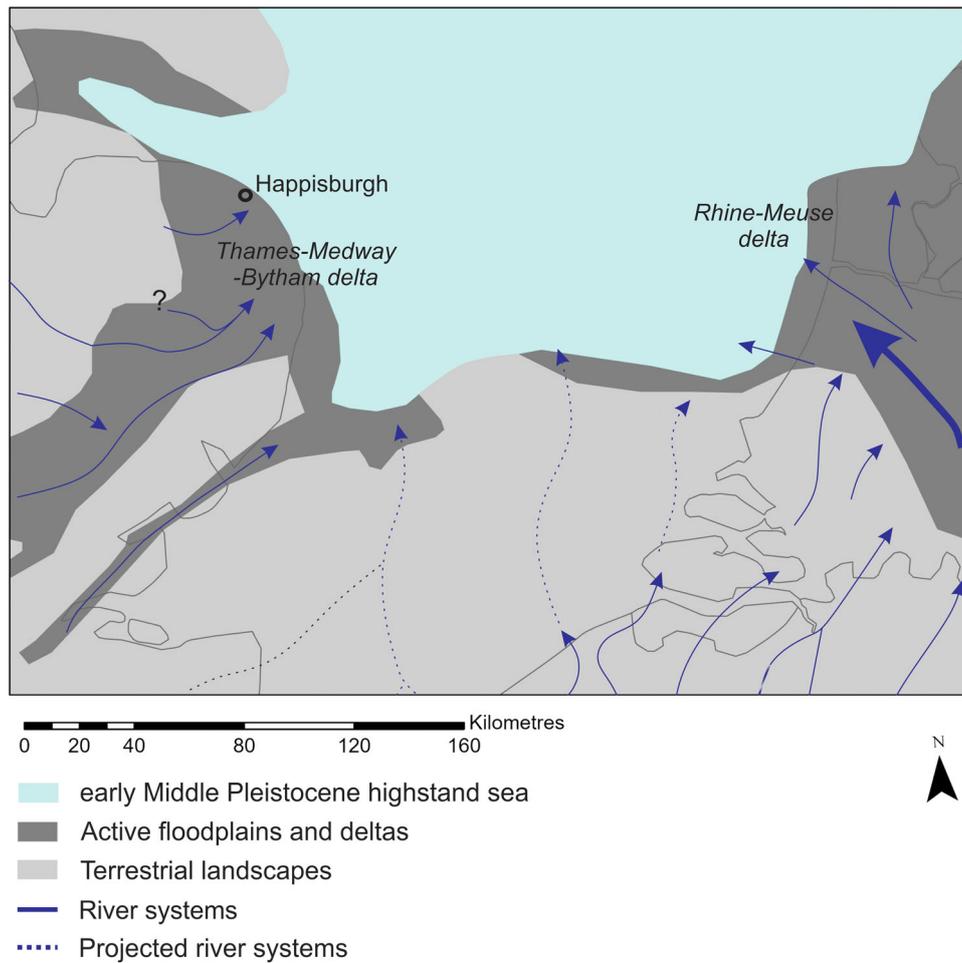


**Figure 1.** The locations of sites and areas discussed in the text as well as currently known extents of the channel deposits in Area A and Area B. The location and status of sea defences and dominant sediment transport direction are also indicated. Inset map shows the location of the study area in red. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

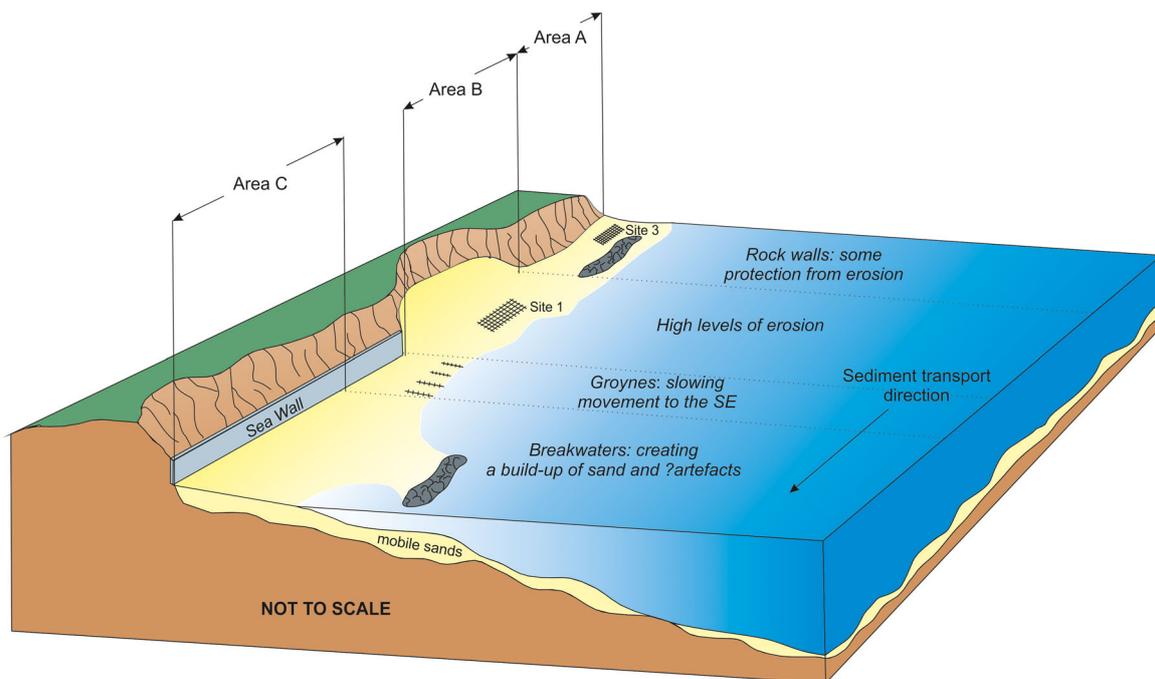
For over 100 years, the CF-bf has yielded important Early to early Middle Pleistocene mammalian fossils and a wealth of other palaeoenvironmental evidence, notably pollen, plant macrofossils, beetles and molluscs. The long history of geological and palaeontological investigation of these deposits has provided an unusually detailed reconstruction of the early Middle Pleistocene landscapes, environments and climate. The CF-bf is no less important for Palaeolithic studies: it was not until recently that hominins were shown to be present, confirmed first by the discovery of artefacts at Pakefield (Parfitt *et al.*, 2005), and further by the aforementioned excavations at Happisburgh Site 1 (0.5 Ma: Lewis *et al.*, 2019) and Site 3 (~0.8–0.9 Ma: Parfitt *et al.*, 2010; Ashton *et al.*, 2014); this is currently the earliest archaeological evidence in northern Europe. At the Happisburgh sites, the association of stone tools with rich environmental evidence shows that hominins were surviving harsh winter conditions (Parfitt *et al.*, 2010; Farjon *et al.*, 2020). This has prompted reappraisal of their technological and behavioural capabilities at such an early date, as well as the nature of migrations after initial African dispersals (Parfitt *et al.*, 2010; Ashton and Lewis, 2012; MacDonald and Roebroeks, 2012; MacDonald *et al.*, 2012; Hosfield *et al.*, 2016; Hosfield and Cole, 2018; Muttoni *et al.*, 2018). The contemporary swathes of now-submerged lowland environments, and their near coastal ecotones, are hypothesised to have provided the resources necessary to attract and support early hominin populations at these latitudes (Cohen

*et al.*, 2012, 2017). If correct, the implication is that Pleistocene deposits submerged by the North Sea, and the CF-bf eroding from the Norfolk coastline, may contain much of the evidence for occupation during this period. Foreshore and cliff erosion of the East Anglian coastline is extensive, however, and is leading to the continued loss of this finite resource, as demonstrated by the very short-lived exposure and subsequent erosion of hominin footprints on the foreshore at Happisburgh in 2013 (Ashton *et al.*, 2014). There is therefore a clear need to develop effective ways of working with these *ex situ* artefacts in order to further understand this unique formation before it disappears completely.

In contrast to the surface scatters found in areas characterised by deflation and time-averaging (e.g. Holdaway and Wandsnider, 2006; Shipton *et al.*, 2018;), or even the disturbance caused in ploughzones (Steinberg, 1996), archaeology recovered from the coast at Happisburgh faces a different problem: this archaeology has been removed from its original context and subjected to movement by varied marine processes (Fig. 3). The approaches taken here attempt to unpick these processes, highlighting new areas of archaeological potential and raising questions about the complexity of this record. Discoveries of *ex situ* beach finds have long provided information about the nature of the deposits they broadly relate to (e.g. Layton, 1827; Reid, 1890; Lister, 1996; Robins *et al.*, 2008), but these finds have often been treated as curios, with little potential to add to our understanding.



**Figure 2.** Reconstruction of the early Middle Pleistocene palaeogeography of the North Sea, showing the main river systems as well as key sites mentioned in the text (after Hijma *et al.*, 2012). [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]



**Figure 3.** Schematic representation of the types of processes working across the study area. [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

Over the last five years, however, there has been a systematic programme to map new surface finds of flint artefacts and Pleistocene mammalian fossils along a 5 km stretch of coast from Happisburgh southeast towards Eccles North Gap (Fig. 1). The finds analysed here consist of flint artefacts and Pleistocene mammalian fossils (Fig. 4). Concreted blocks of CF-bF, often with organic inclusions such as leaf imprints and pine cones, are also found along this coastline. Never having been recognised *in situ*, however, these are presumed to have been formed underwater and washed onshore; this assertion has held since the late 19<sup>th</sup> century when areas of rocky seabed were found 'at half-a-mile north-north-east of the Low Lighthouse' at Happisburgh (Reid, 1890: 173). This concreted material has been found adhering to flint artefacts included within this analysis.

A simple hypothesis of artefact and fossil movement in the marine littoral would be that assemblages would become homogenised by wave action and long-shore drift, with patterns relating only to transport and the durability of artefacts and fossils. Previous work on the large mammal remains recovered from the foreshore, however, has identified patterning in the record in terms of species and chronological groupings in collections from different locations (e.g. Lister, 1996). Similarly, a survey of historical handaxe finds from the same stretch of Norfolk and Suffolk coast (Robins *et al.*, 2008) has identified clusters of Palaeolithic finds in areas where Palaeolithic artefacts are now known to occur *in situ* within the CF-bF. This is taken further by the in-depth analysis provided

here. By combining the spatial patterning of finds with geological information, the dominant sediment transport in this area and the constraints on this movement (Fig. 3), it is possible to demonstrate a more nuanced pattern than simple hypotheses would suggest and highlight potential areas of previously unrecognised archaeological interest both above and below the waterline.

This study develops a systematic methodology for working with *ex situ* Palaeolithic finds in coastal and intertidal locations. The results allow the finds to be placed within a framework that aids the understanding and interpretation of the wider archaeological landscape. Crucially, this work has identified the potential of unexplored exposures both onshore and in the offshore zone. The methods used in this study will also be of wider application in other coastal and intertidal areas where Pleistocene sediments contain fossil and archaeological materials.

## Geological background

The CF-bF is an extensive and complex series of river and estuarine deposits that can be found at the base of the cliffs and beneath the foreshore around the coasts of Norfolk and northern Suffolk (Fig. 5; West, 1980; Lee *et al.*, 2015). The CF-bF infills part of the Crag Basin and interdigitates with Crag sediments, which are marine in origin. The overlying cliffs are predominantly composed of a series of glacial sediments,



**Figure 4.** Examples of Pleistocene mammalian remains and flint artefacts as found in the study area (all photo credits: D. Nicholas and J. Leonard): (a) abraded Elephantid bone fragment near the waterline in Area C; (b) fresh handaxe over the Borehole HC exposures in Area A; (c) *Bison sp.* metacarpal at the shoreline in Area B; (d) Site 1 deposits exposed on foreshore, walking stick showing find-point of an *ex situ* artefact; (e) *ex situ* handaxe in Area A; (f) *ex situ* core in Area A. [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]



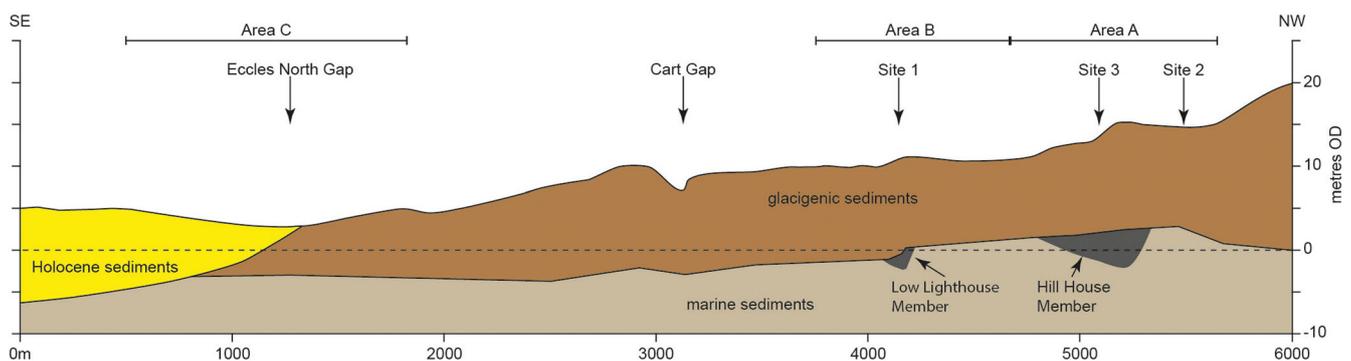
**Figure 5.** (a) Site 1 Low Lighthouse Member, exposed in 2018 during a period of rapid erosion of these deposits (credit: S. Lewis); (b) exposure of Hill House Member, exposed in 2018 in the vicinity of HC and old step tower, also showing failure of sea defences (credit: S. Lewis); (c) 2018 beach conditions at Eccles North Gap, showing the start of the shore-parallel beach defences, looking southeast (credit: R Bynoe); (d) 2017 exposures in the area of high-density beach finds at HC (credit: J. Leonard and D. Nicholas). [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

including the Happisburgh Formation that most researchers now attribute to the Anglian Glaciation (MIS 12), dating to c. 0.47 Ma (Preece *et al.*, 2009; Preece and Parfitt, 2012; for an alternative interpretation see Lee *et al.*, 2004). This cover of glacial sediments is significant for two reasons: first, the water-lain nature of the initial incursion that deposited the Happisburgh Till served to bury, rather than destroy, the underlying deposits of the CF-bF (Rose *et al.*, 1976; Rose, 2009; Cohen, 2017). Second, the extensive nature of the glacial deposits also means that the CF-bF deposits are buried, with limited 'windows' largely restricted to the foreshore where the tills have been washed away.

An extensive programme of research has been carried out to investigate the CF-bF deposits at Happisburgh, with a particular focus on Sites 1 and 3. Both consist of channel-fill deposits cut into marine sands and overlain by Happisburgh Till (Fig. 6). At Site 1 these sediments (the Low Lighthouse

Member of the CF-bF) contain a wide range of environmental material together with flint artefacts, including a handaxe, and cut-marked bones (Ashton *et al.*, 2008; Lewis *et al.*, 2019). The faunal remains, including *Arvicola* (water vole), suggest an age in the later part of the early Middle Pleistocene, probably equivalent to MIS 13 (Lewis *et al.*, 2019).

Site 3 lies c. 1 km to the north-west of Site 1 on the northern edge of an ~700-m-wide series of channels. In the area of Site 3 the channel is filled with a complex sequence of gravels and estuarine sandy silts (the Hill House Member of the CF-bF, previously designated the Hill House Formation by Parfitt *et al.*, 2010). Similar gravels and estuarine sediments were identified by West (1980) in a borehole located at the former lifeboat slipway (HC, Fig. 1) c. 300 m to the southeast of Site 3. These laminated sediments pinch out about 100 m southeast of HC (Ashton *et al.*, 2018) which may mark the southern edge of the Site 3-HC channel complex (Figures 1 and 6). The age of



**Figure 6.** Generalised section from Eccles North Gap in the south to Walcott Gap in the north, showing the locations of CF-bF in Areas A and B, as well as the lack of known CF-bF deposits to the southeast. [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

the Hill House Member and the associated archaeology has been constrained through the reversed palaeomagnetic signal from the sediments and biostratigraphy, suggesting an age between 0.78 and 1 Ma (Parfitt *et al.*, 2010).

The Hill House Member has yielded a rich array of environmental evidence, suggesting the site was situated in an open grassland valley, surrounded by coniferous forest with winter temperatures several degrees lower than East Anglia today (Parfitt *et al.*, 2010; Farjon *et al.*, 2020). The excavated archaeological assemblage of 80 artefacts consists of simple flint flakes, flake tools and cores, but no handaxes. In 2013, an exposure of the estuarine silts, c. 100 m to the southeast of the main excavations, revealed a surface retaining human footprints including those of children (Ashton *et al.*, 2014; Wiseman *et al.*, 2020).

A programme of drilling, supplemented by onshore and offshore geophysics, has established the extent of the Site 1 and Site 3 channel deposits (Ashton *et al.*, 2018). Progressive failure of the sea defences along the Happisburgh frontage has resulted in significant beach scour, which has revealed further exposures of Pleistocene sediments that are the subject of continuing investigations. From Site 1 southwards to Eccles North Gap there is a significant lack of boreholes and there are currently no known outcrops of the CF-bF.

Exploration of the offshore zone through marine geophysical data collection and targeted diving is also being undertaken to establish whether the onshore channels or other CF-bF deposits survive offshore (Bynoe *et al.*, forthcoming).

## Material and methods

### *The datasets and collection areas*

The beach deposits in this area comprise sand, with the aforementioned cliff geology of till, clays, sands and gravel. With a linear coastline facing northeast, the coastline is exposed to a wide range of wave directions, with waves from the north having almost unlimited fetch and thus having the potential to be particularly destructive (Poulton *et al.*, 2006). The levels of the beach also vary significantly, changing by up to 2 m in a single storm event; it is a remarkably dynamic environment with considerable movement of sediment and artefacts possible.

The flint artefacts and mammalian fossils were collected between 2013 and 2017 during several visits per month by three of the authors (DN, JL and TG). The foreshore was walked extensively, each visit lasting 3–4 h and covering several kilometres. All foreshore areas between Eccles North Gap and Happisburgh (a distance of 5 km) were searched but with efforts concentrated in these two areas. The locations of surface finds were recorded, regardless of identifiability or condition, using a hand-held GPS. Despite the intention to collect all artefacts, it is accepted that this is likely to be unintentionally biased towards those that are larger and more visible.

For the analyses three collecting areas (A–C) have been defined. These broadly relate to known locations where *in situ* Palaeolithic artefacts have been recovered (A and B) and another location (C) where a particularly high concentration of beach finds has been identified (Fig. 1). Area A is located over the most extensive spread of CF-bF deposits that includes Site 3, the footprint horizon, and HC. Area B adjoins and extends from Area A, encompassing Site 1, to the start of the concrete sea-defences. The only known CF-bF deposits in this area are those of Site 1. Area C extends just to the northwest of Eccles North Gap to the start of the breakwaters to the southeast.

There are no known exposures of CF-bF in this location (Fig. 6).

The finds are affected by the dominant sediment transport in this area, which is also modified by the local sea defences (Figures 1 and 3). Numerical modelling of particles in the nearshore and offshore environment show the long-shore direction of this movement to be overwhelmingly south-eastwards, moving parallel to the shore (Figures 1 and 3; HR Wallingford *et al.*, 2002), although with the potential for some movement in the opposite direction during storm surges (Dolphin *et al.*, 2012). In support of this, time-step bathymetry from 2011 and 2016 Environment Agency multibeam bathymetry, out to 1 km from shore (data.gov.uk), shows that sand-waves and seabed debris such as shipwrecks are moving parallel to the shoreline in a southeasterly direction. It is highly likely that the dominant movement of finds will follow this pattern.

The beach and cliffs from Happisburgh to Eccles North Gap are defended by groyne, sea walls and shore-parallel breakwaters, in varying states of repair. In Area A the shore-normal groyne to the northern extent are in a fair state of repair, but the shore-parallel defences are severely damaged and offer little impediment to sediment movement. In the embayment of Area B the defences have been removed or are defunct. Material transported along the coast to the southeast from these areas is likely to be slowed down, or trapped, by the active defences, which start at the southern extent of Area B and continue for 2.5 km to the southeast at Eccles North Gap (Fig. 1). The southern extent of Area C marks the start of a series of nine shore-parallel rock-built breakwaters (the Sea Palling reefs) which have encouraged the build-up of sand between the breakwaters and the shore. This is particularly the case at the northwestern end of these defences, within Area C, where the altered tidal regime around the first of the breakwaters has led to a build-up of sand both on the beach and in the nearshore zone. This may also act to accumulate artefacts and fossils.

### *Analyses*

The flint artefacts were analysed according to the system of Ashton and McNabb (1994), including assessments shown in Tables 1–3. Artefact condition relates to the smoothing of edges and arretes during transport and was determined visually, on a scale of 1–3, with 1 being very fresh and 3 being very rolled. Patination and staining refer to the surface characteristics of the artefact and were visually assessed on a three-point scale. Artefact assemblages from Sites 1 and 3 are fresh, unpatinated and unstained, so the more rolled condition recorded in this analysis either relates to *ex situ* movement of material derived from these sources, or the artefacts are derived from other, unknown, sites. The distal index is a measure of the amount of flaking from the distal end, calculated as the percentage of flake scar patterns (types 4, 6, 7, 9, 11, 12) that include

**Table 1.** Artefact types present in each Area.

Type	Area A		Area B		Area C	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Cores	16	13.8	16	11.9	16	3.3
Hard hammer flakes	92	79.3	116	85.9	469	95.7
Soft hammer flakes	1	0.9	0	0	0	0
Flake tools	2	1.7	1	0.7	4	0.8
Handaxes	5	4.3	2	1.5	1	0.2
Total	116	100	135	100	490	100

**Table 2.** Basic statistics on dimensions of all flakes and flake tools from each area (IQR = interquartile range).

Flake dimensions	Area A			Area B			Area C		
	Mean	Median	IQR	Mean	Median	IQR	Mean	Median	IQR
Length (mm)	50.9	49.0	21.0	49.0	46.5	21.5	46.0	44.0	21.0
Width (mm)	44.2	41.0	20.0	47.0	41.5	23.5	41.0	40.0	15.5
Thickness (mm)	14.9	12.4	9.5	14.0	13.0	7.2	13.0	11.6	6.9
Weight (g)	43.2	23.2	27.5	43.0	28.6	35.3	32.0	23.0	28.8

**Table 3.** Condition and technological attributes for flakes in each Area.

		Area A		Area B		Area C	
		<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Total		95		117		473	
Condition	1-very fresh	4	4.2	2	1.7	6	1.3
	1/2-fresh	8	8.4	14	12.0	40	8.5
	2-slightly rolled	40	42.1	44	37.6	173	36.6
	2/3-rolled	33	34.7	46	39.3	172	36.4
Patination	3-very rolled	10	10.5	11	9.4	82	17.3
	0-unpatinated	95	100	116	99.1	431	91
	1-slightly patinated	0	0	1	0.9	41	9
Staining	2-patinated	0	0	0	0	1	0
	0-unstained	95	100	117	100	471	99.6
Cortex	1-slightly stained	0	0	0	0	1	0.2
	2-stained	0	0	0	0	1	0.2
	100% cortex	1	1.1	2	1.7	28	5.9
	>50% cortex	10	10.5	14	12.0	73	15.4
Number of dorsal scars	<50% cortex	51	53.7	70	59.8	250	52.9
	No cortex	33	34.7	31	26.5	122	25.8
	0	2	2.1	6	5.1	35	7.4
	1	10	10.5	8	6.8	105	22.2
	2	14	14.7	27	22.9	110	23.3
	3	18	18.9	21	17.8	98	20.7
	4	14	14.7	20	16.9	67	14.2
	5	11	11.6	16	13.6	36	7.6
	6	9	9.5	11	9.3	13	2.7
	7	7	7.4	3	2.5	7	1.5
Dorsal scar pattern	8	5	5.3	3	2.5	2	0.4
	9	3	3.2	1	0.8	0	0.0
	10	2	2.1	2	1.7	0	0.0
	1-proximal	23	24.2	31	26.3	154	32.6
	2-proximal, L/R lateral	30	31.6	33	28.0	124	26.2
	3-proximal, L + R lateral	5	5.3	6	5.1	19	4.0
	4-proximal, L/R lateral, distal	10	10.5	9	7.6	23	4.9
	5-L/R lateral	6	6.3	5	4.2	46	9.7
	6-distal	0	0.0	1	0.8	17	3.6
	7-proximal, distal	7	7.4	9	7.6	27	5.7
	8-L + R lateral	1	1.1	5	4.2	8	1.7
	9-proximal, L + R lateral, distal	5	5.3	4	3.4	9	1.9
10-cortical	2	2.1	6	5.1	33	7.0	
11-L/R lateral, distal	0	0.0	4	3.4	6	1.3	
12-L + R lateral, distal	6	6.3	5	4.2	7	1.5	
Total	Distal index	29.5		26.5		19.2	
Butt type		95		118		473	
	Plain	65	68.4	93	78.8	327	69.1
	Dihedral	4	4.2	0	0.0	10	2.1
	Cortical	17	17.9	21	17.8	92	19.5
	Missing	2	2.1	1	0.8	5	1.1
	Marginal	5	5.3	3	2.5	22	4.7
	Natural	2	2.1	0	0.0	4	0.8
	Soft hammer	0	0	0	0	10	2.1
Mixed	0	0	0	0	3	0.6	

**Table 4.** Statistics for dimensions of mammalian fossil assemblages from each area.

Dimensions	Area A (n = 49)				Area B (n = 83)				Area C (n = 25)			
	Mean	SD	Med	IQR	Mean	SD	Med	IQR	Mean	SD	Med	IQR
Length (mm)	110.6	69.8	97.3	66.6	126.9	63.6	118.9	65.0	119.0	55.0	111.4	79.6
Width (mm)	57.2	28.1	55.0	39.0	66.9	37.6	58.2	52.7	70.9	36.6	59.9	56.7
Weight (g)	298.1	387.9	162.5	276.5	396.5	429.1	240.0	496.6	324.1	308.6	237.0	432.1

removals in an opposed direction to the actual flake (see Table 3). Higher values of the distal index usually reflect more complex knapping.

The mammalian fossils were analysed at the Natural History Museum, London, where they were identified using reference collections and assistance from Adrian Lister who identified deer and elephant remains, and Fred Owen who identified the horse teeth. Attributes recorded include taxon and body part, fragment size dimensions (Table 4), as well as levels of abrasion and mineralisation (Table 5).

Abrasion for fossil finds was classified from 0 (no abrasion) to 3 (very abraded/rounded). Similarly, mineralisation is on a numerical scale from 1 (unmineralised/modern) to 3 (heavily mineralised).

Where basic statistics on dimensions are used, these have taken into account the non-normal distribution of the data. As such, the key statistics are the median values and the interquartile ranges, which are less affected by any skew or major outliers in the data. Mean values have been presented for interest and as a comparison with median values.

Spatial data were collected by GPS in WGS-84 and imported into ArcGIS Pro 2.5.0 where they were projected into OSGB-36. Spatial analysis was carried out using kernel densities with each assemblage considered as a whole (fossil and stone tool, inclusive of Areas A, B and C) and for fossils and artefacts within each of the Areas. These are presented on a simple, increasing scale from lowest to highest density, as the numerical values differed between areas (with different surface area and numbers of finds). Optimised Hot Spot Analysis in Arc Pro 2.5.0 was also utilised. This uses the Getis-Ord  $G_i^*$  statistic to identify statistically significant spatial clusters of high and low values from point data.

**Table 5.** Condition of mammalian fossils in each area.

		Area A		Area B		Area C	
		n	%	n	%	n	%
Total		49		83		25	
Abrasion type	1–fresh	0	0.0	0	0.0	0	0.0
	2–slightly abraded	6	12.2	11	13.3	2	8.0
	3–moderately abraded	21	42.9	41	49.4	13	52.0
	4–very abraded	22	44.9	31	37.3	10	40.0
Mineralisation type	1–unmineralised	0	0.0	2	2.4	0	0
	1/2–slightly mineralised	2	4.1	3	3.6	1	4.0
	2–moderately mineralised	25	51.0	36	43.4	13	52.0
	2/3–mineralised	14	28.6	28	33.7	9	36.0
	3–very mineralised	8	16.3	14	16.9	2	8.0

## Results

Kernel density plots of the stone tool and fossil assemblages are shown in Fig. 7a–c. As expected, there are higher densities of both flint artefacts and fossils in the vicinity of Site 3 and Site 1. Artefact densities are also high to the southeast of these sites, a pattern that is seen to a lesser extent with the fossils. At Eccles North Gap there is also a high-density area of finds, particularly for the flint artefacts. A notable feature throughout the study area is the difference in distribution between the flint artefacts and the fossils with a more diffuse spread of the latter.

With 66% of the total flint artefact assemblage found in Area C, the patterns in the densities of artefacts elsewhere will therefore be muted. The density patterns in Areas A and B are shown in more detail with Area C removed (Fig. 7b).

### Artefact patterning in Areas A to C

There are 741 lithic artefacts, generally made of the same type of black flint, mostly appearing to derive from flint cobbles. The artefacts consist of a small number of handaxes and flake tools, a moderate number of cores and the vast majority being unretouched hard hammer flakes. There is just one soft hammer flake, found in Area A (Table 1). Table 2 shows the statistics for flake dimensions from each area. Each area has a similar range, with Area C having marginally smaller median values and interquartile ranges.

There are similar proportions of stone tool types across the areas, although with an increase in the numbers of flakes in Area C and the highest number of handaxes (and a single soft hammer flake) from Area A. The condition of the artefacts also shows similarities, but with the freshest material deriving from Area A and an increase in the most abraded material in Area C. Similarly, staining and patination are more prevalent in Area C (Table 3). Levels of cortex are also relatively similar throughout the three areas, but with Area A having the fewest artefacts with a fully cortical dorsal side.

All three areas are dominated by plain and cortical butts (Table 3), with flake scars ranging from one to 10 for Areas A and B, peaking at three and two scars per flake respectively. Area C has a slightly reduced range, from one to eight, and with flakes per scar peaking at two.

The distal index for Areas A and B again is comparable, at 29.5 and 26.5 respectively, both showing that most flaking was from the proximal and lateral edges. Area C, however, has an even lower distal index of 19.2, showing a greater dominance of flaking from proximal and lateral directions. The lower flake scar counts and distal index for Area C could be an indication of a less complex knapping strategy. However, the combination of higher levels of cortex and the smaller size of the flakes may suggest the use of smaller nodules for knapping, which would affect flake scar counts and knapping from opposed ends.

**Table 6.** Counts of taxa present in each area.

	Area A	Area B	Area C
<b>Mammalia</b>			
<b>Carnivora</b>			
<i>Crocuta crocuta</i>	–	–	1
<i>Ursus</i> sp.	–	1	2
<b>Proboscidea</b>			
<i>Mammuthus meridionalis</i>	6	2	1
<i>Mammuthus trogontherii</i>	1	1	1
<i>Elephantid</i> sp. Indet.	13	37	3
<b>Perissodactyla</b>			
<i>Equus mosbachensis</i>	–	2	–
<i>Equus altidens</i>	–	1	–
<i>Equus</i> sp.	4	1	1
<i>Rhinoceros</i> sp.	2	4	2
<b>Artiodactyla</b>			
<i>Bos</i> sp.	2	1	3
<i>Bovidae</i> sp.	2	5	3
<i>Cervalces latifrons</i>	2	–	1
<i>Cervus elaphus</i>	–	1	–
<i>Cervus</i> sp. Indet.	4	13	6
<i>Eucladoceros sedgwickii</i>	–	1	–
<i>Hippopotamus</i> sp.	3	–	–
<i>Megaloceros dawkinski</i>	–	–	1
<i>Megaloceros</i> sp. Indet.	1	–	–
<b>Unidentified</b>	9	13	0

**Table 7.** Basic statistics of artefacts from high-density areas over Site 3 and HC within Area A and Groups 1 and 2 from Area B, as well as low-density spread within Area B.

Length (mm)	Area A		Area B		
	High density	Low density	High density Group 1	High density Group 2	Low density
Mean	51	50	55	49	47
Median	50	47	57	46	46
IQR	21	21	24.3	20.5	20
<b>Weight (g)</b>					
Mean	48	36	70	46	36
Median	23.2	23	38.1	30	25.1
IQR	34	25.8	44.5	29.6	36.8

### Distribution patterns

Density plots of artefacts by abrasion category have been used to assess potential transport history, as abrasion should be expected to increase with distance travelled.

#### Area A

Figure 8 shows that the least abraded material from Area A is located over the Site 3 deposits and, in particular, in the vicinity of HC, with the locations of these higher density plots moving to the southeast with increasing abrasion. This patterning indicates movement, and abrasion, in line with dominant transport directions from what appear to be source areas of fresh lithic artefacts over Site 3 and HC. Further assessment of the artefact dimensions supports this, showing that those associated with these high-density areas are both larger and heavier, with an increased range of variation

relative to those elsewhere in Area A (Table 7). Further investigation of Area A is required to understand more clearly whether the CF-bF deposits cropping out near HC contain *in situ* artefacts in the abundance suggested by these results.

One potentially significant result relates to the finds of five handaxes and a thinning flake. Four of these handaxes and the thinning flake were recovered from areas of known exposures of the CF-bF (Fig. 9), with one remarkably fresh handaxe found near HC (Figures 9 and 10). The handaxe from the southern extent of Area A is very abraded. The implications of these finds will be explored in the Discussion.

#### Area B

The densities of artefacts show two main concentrations (Fig. 10), with a persistent gap between. The first, Group 1 ( $n=24$ ), is spatially associated with the Site 1 sediments, but the second, Group 2 ( $n=60$ ), is to the southeast of any known CF-bF foreshore exposures. Mean sizes and weights are smaller in Group 2, with less size variation as well as higher levels of abrasion (Table 7). A small number of artefacts to the northwest of Area B are on average lighter than Groups 1 and 2 and possibly dispersed through wave action (Dolphin *et al.*, 2012), or potentially through movement from Area A. While the small sample sizes, of Group 1 in particular, necessitates cautious interpretation, the above data, in addition to the persistence of the gap between the two groups, suggest that this pattern is real and may reflect a difference in the location of their source areas, rather than a collection bias.

#### Area C

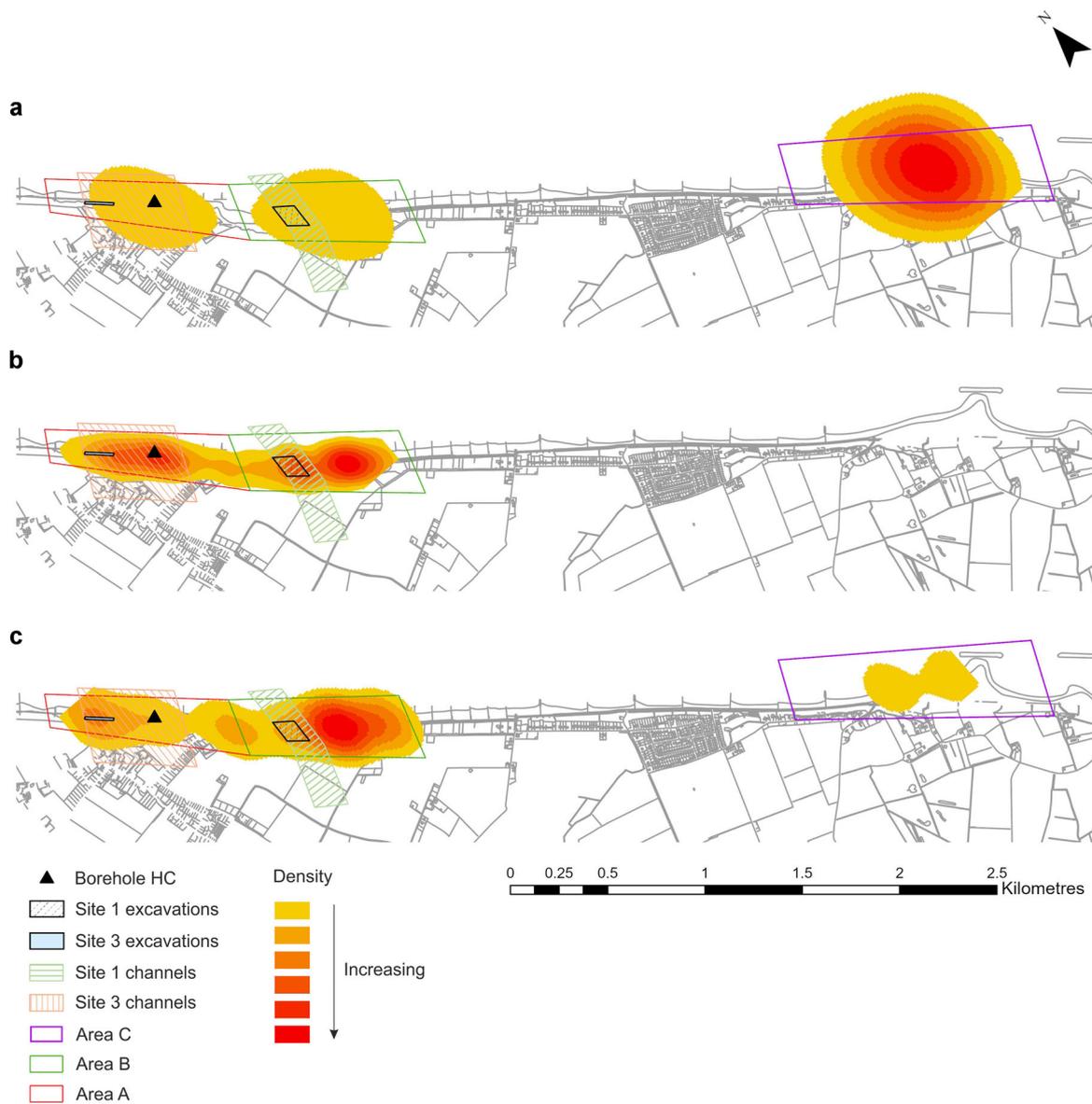
The distribution shows an increasingly dense concentration towards the southeast (Fig. 11). This probably reflects sediment transport, with artefacts accumulating due to the build-up of sand between the breakwater and the shore. The smaller size, reduced variation and increased abrasion of the artefacts compared to other areas suggest that the scatter has been subject to size sorting and has been transported further. The source of the material is not known but is likely to be CF-bF deposits offshore.

#### Hot spot analysis

Similar to the pattern shown in Fig. 7, optimised hot spot analysis shows that Eccles North Gap has a statistically significant density of artefacts (Fig. 12). As discussed, however, the disproportionately high numbers of artefacts found here will mask patterns from the two other areas. Figure 12 therefore also shows hot spot analysis that has been carried out on Areas A and B, with Area C removed. As indicated by the kernel densities, the concentrations of flint artefacts that show statistical significance are over HC in Area A and Group 2 in Area B.

#### Mammalian fossil patterns from Areas A to C

The fossil assemblage consists of 157 specimens distributed throughout the three areas (Table 4) of which 135 can be identified to taxon, usually to genus and occasionally to species (Table 6). Biostratigraphically significant species broadly fall into three groups (Fig. 13). First, the combantlered deer (*Eucladoceros sedgwickii*) is an Early Pleistocene species that became extinct before the start of the early Middle Pleistocene. A primitive mammoth (*Mammuthus meridionalis*) can also be considered as an Early Pleistocene species



**Figure 7.** Density plots showing (a) overall flint artefacts; (b) overall mammalian fossil finds; and; (c) flint artefacts with Areas A and B only. Densities are shown on an increasing scale from yellow to red. [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

although there are indications of its survival into the early Middle Pleistocene before it was replaced by *M. trogontherii* (Lister, 1996). A second and larger group of species have a first appearance date in the early Middle Pleistocene [*Mammuthus trogontherii* (steppe mammoth), *Megaloceros dawkinski* (giant deer), *Crocota crocuta* (spotted hyaena), *Hippopotamus* sp. (hippo), *Equus altidens* and *Equus mosbachensis* (horse) (Azzaroli, 1996)]. A third group comprises long-ranging species: *Cervalces latifrons* (extinct elk), which appears ~1 Ma and exists through into the early Middle Pleistocene, and *Cervus elaphus* (red deer), which appears at ~1 Ma and exists to the present.

Table 4 shows the dimensions of the bones and bone fragments recovered across the three areas, with Area A having the smallest, and Area B the largest, mean size and weight. This may in part be due to the prevalence of large and dense Elephantid remains from Area B. Abrasion levels are similar for Areas A and B, with Area C showing marginally higher levels. Mineralisation, on the other hand, is similar between Areas A and C (type 2, comparable to remains from Sites 1 and 3), with Area B having the highest proportion of heavily mineralised remains (type 3).

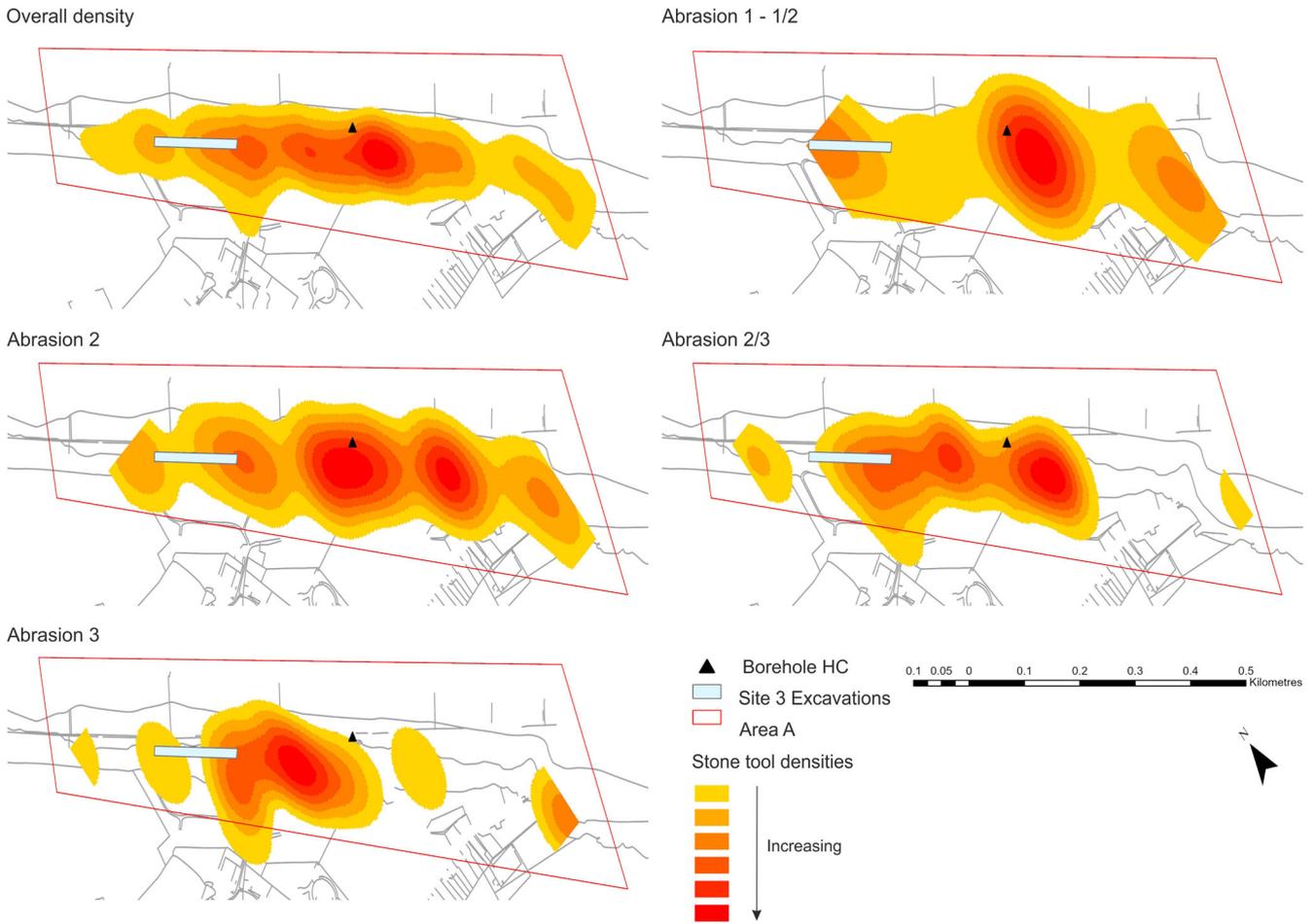
## Species attributions and distributions

### Area A

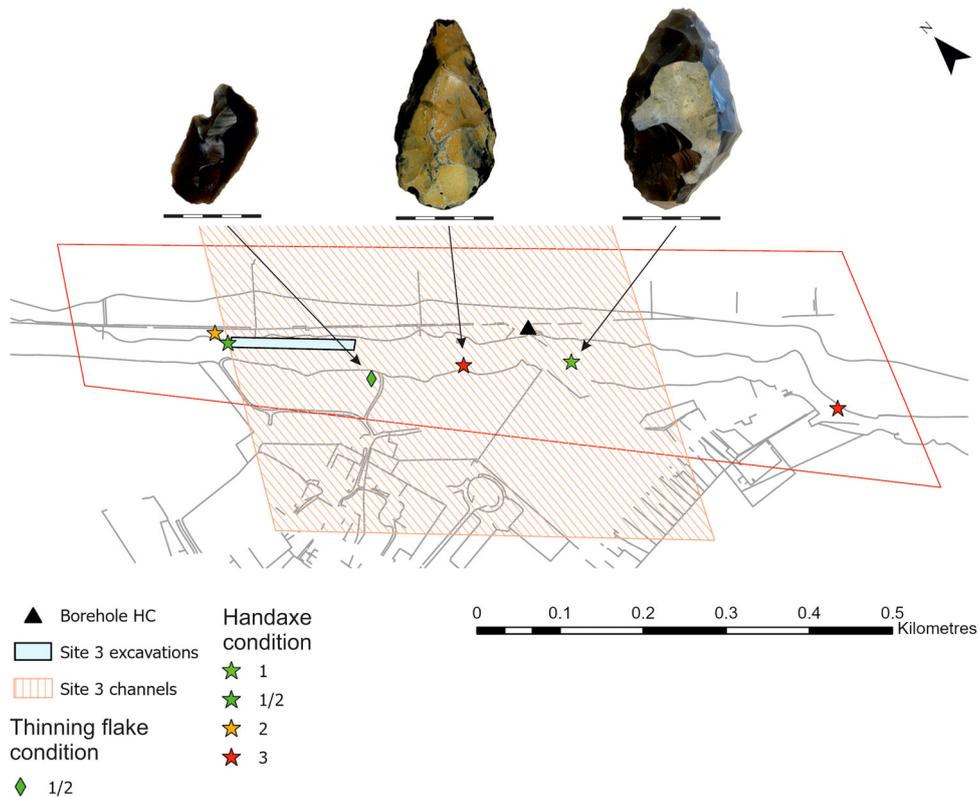
Elements identified to species are rare in the assemblage, due to its fragmentary and abraded nature (Table 5). Elephants make up over half the composition of the material, with four of the identifiable elephant molars being *M. meridionalis* and three of these found overlying Site 3 deposits (Fig. 14). There is one probable *M. trogontherii* molar, which was recovered at the southern extent of Area A.

Other identified taxa include the only instance from this analysis of hippopotamus, a species generally considered to indicate warm climatic conditions, and *C. latifrons* in a higher proportion than in the other areas. The assemblage is broadly comparable to the large mammals associated with Site 3: *M. meridionalis* and *C. latifrons* (Parfitt *et al.*, 2010).

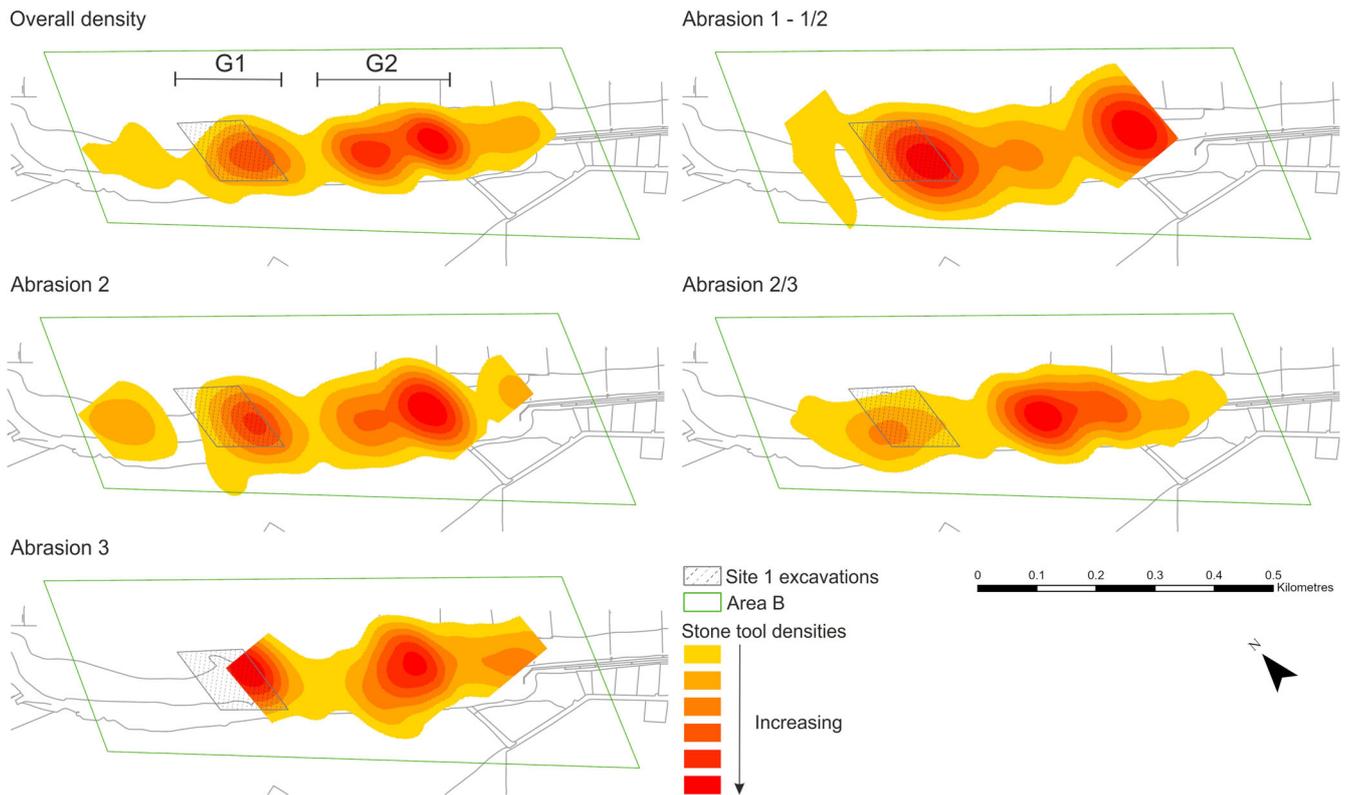
The predominant mineralisation type of these specimens, Type 2, is also consistent with finds from Site 3. The fossils are concentrated over the Site 3 deposits with a spread of relatively less dense material found moving to the southeast of this area, in the vicinity of HC (Fig. 14) and at the southeastern extent of Area A.



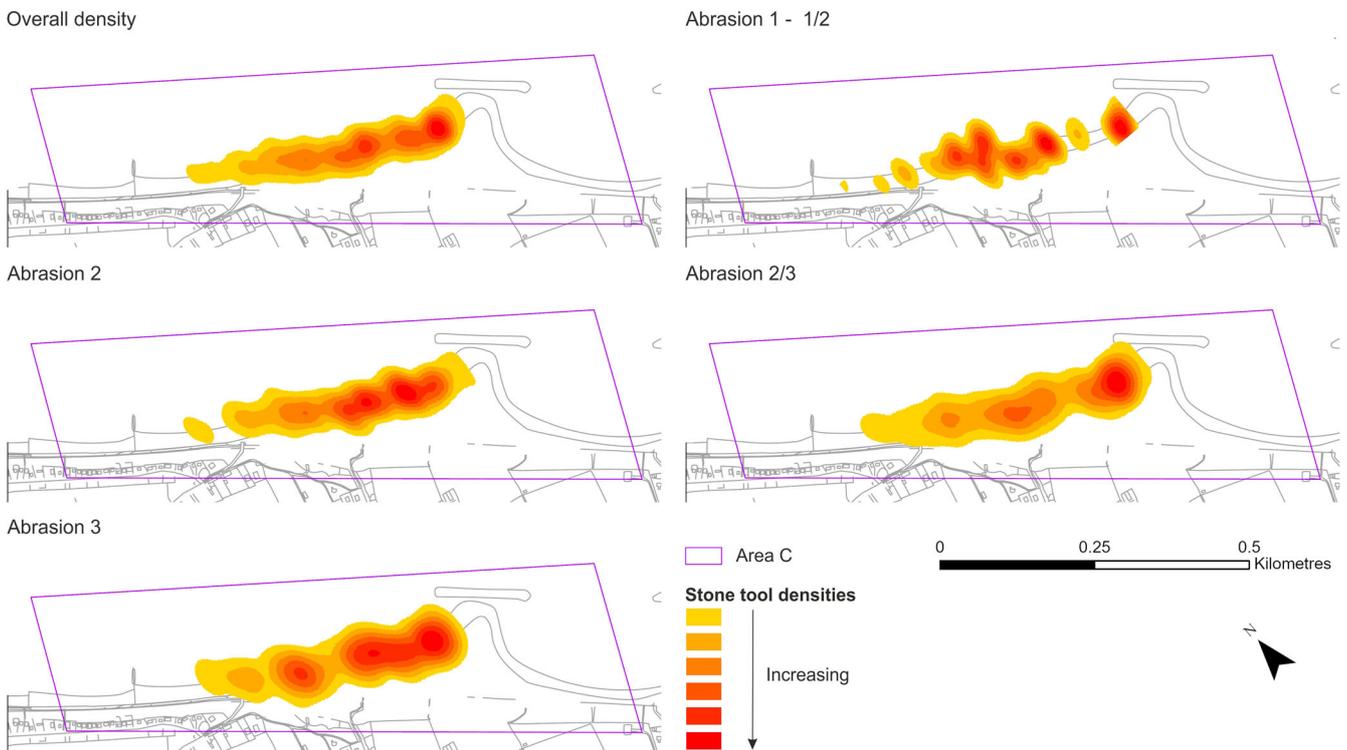
**Figure 8.** Densities of lithics in Area A, showing the total density of all finds in this area (top), followed by the density spread for each abrasion class from 1–1/2 (very fresh) to 3 (very abraded). Density is shown on an increasing scale. [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]



**Figure 9.** Locations of handaxes and thinning flakes in Area A in relation to Site 3 and HC. [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]



**Figure 10.** Densities of lithics in Area B, showing the total density of all finds in this area (top), followed by the density spread for each abrasion class from 1–1/2 (very fresh) to 3 (very abraded). Density is on an increasing scale. [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

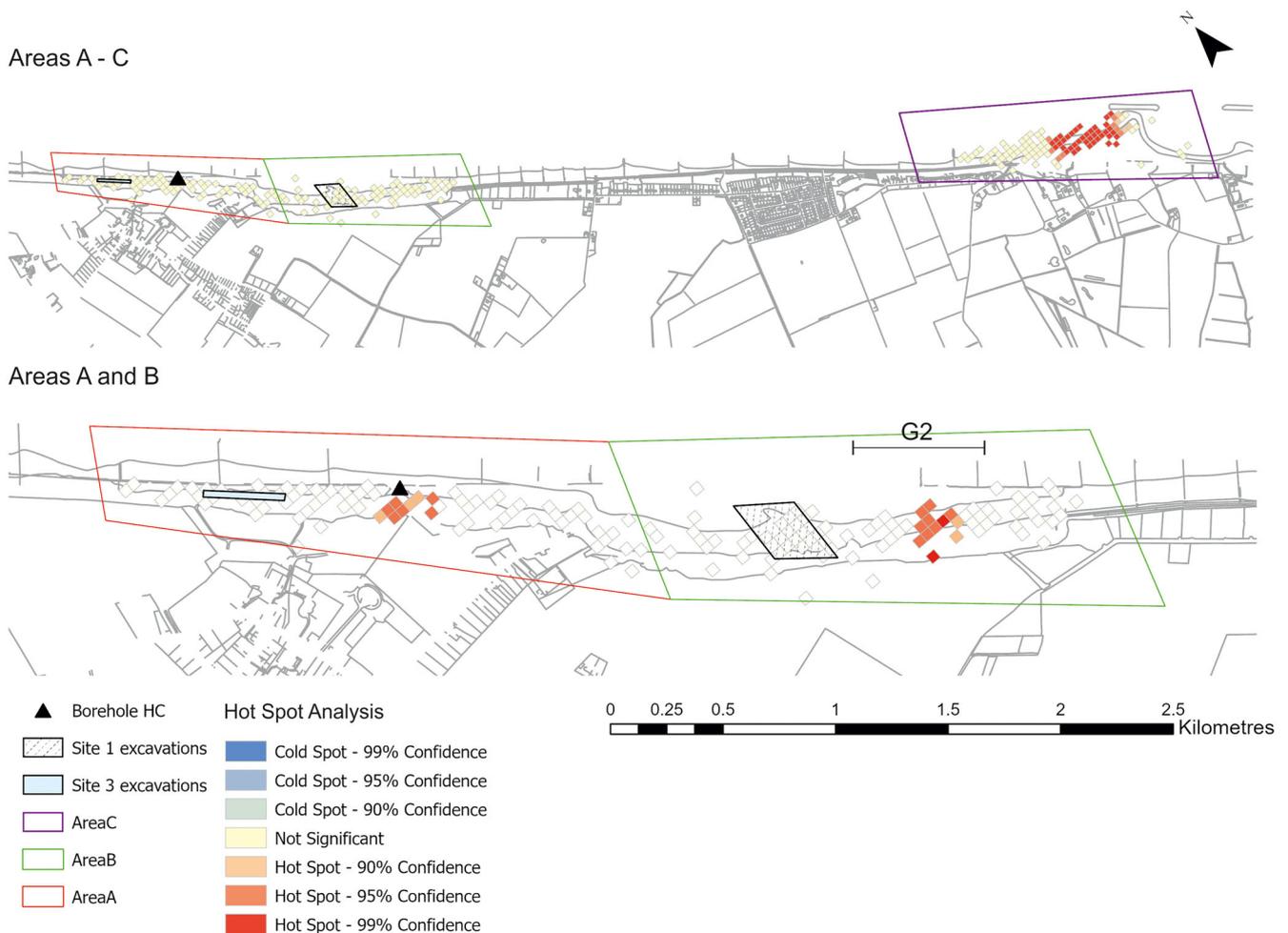


**Figure 11.** Densities of lithics in Area C, showing the total density of all finds in this area (top), followed by the density spread for each abrasion class from 1–1/2 (very fresh) to 3 (very abraded). Density is shown on an increasing scale. [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

#### Area B

More than half the specimens here are Elephantids, with a high proportion of deer (Table 5). There are smaller proportions of other species groups; hippopotamus and elk are not represented. Where species can be identified, the elephant remains

show two *M. meridionalis* to one *M. trogontherii* molar. Of the deer, there is an antler of *Cervus elaphus*, and another from the Early Pleistocene *Eucladoceros sedgwickii*. Of the four horse teeth, three are identifiable to early Middle Pleistocene species *Equus mosbachensis* and *Equus altidens*. The Area B assem-



**Figure 12.** Optimised Hot Spot analyses of the lithic assemblage as a whole and for Areas A and B only. Statistically significant areas are shown in Area C, HC in Area A and Group 2 (G2) in Area B. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

blage thus includes both Early Pleistocene and early Middle Pleistocene elements, suggesting that the fossils are derived from at least two sources (Figures 14 and 15). The elements of the assemblage identified to species were all found to the southeast of Site 1, except one *M. trogontherii* molar found to the north-west.

As with the flint artefacts, the distribution seen in Area B is more complex (Fig. 14), possibly owing to the lack of sea defences and so higher potential for movement of material in this area. The fossils are concentrated to the southeast of Site 1 ( $n = 40$ ), in an area with a high concentration of artefacts (i.e. Group 2; Fig. 10), with smaller concentrations of finds tapering-off to the southeast. The extent of abrasion is similar in both concentrations, although the sample size from the Site 1 location is very small ( $n = 13$ ).

#### Area C

In contrast to both Areas A and B, Area C has fewer Elephantid remains, with more than half the assemblage made up of bovids and deer. Area C is also unusual in having the highest proportions of carnivores compared to other areas, represented by spotted hyaena (*Crocota crocuta*) and bear (*Ursus* sp.) (Table 6). Of the identifiable elephant molars, there is one specimen each of *M. meridionalis* and *M. trogontherii*. Cervids include a single specimen of early Middle Pleistocene *M. dawkinski* and *Cervalces latifrons* (Table 6). There are no known CF-bF deposits in the area, but the inclusion of an Early

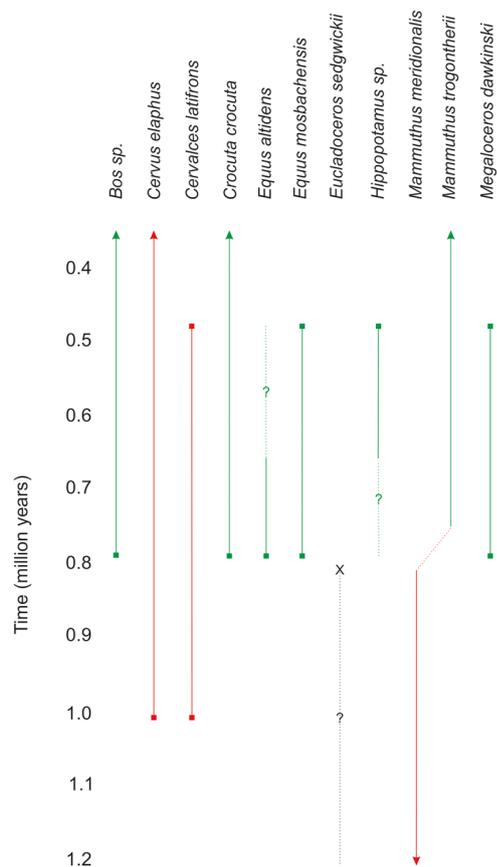
Pleistocene fossil (*M. meridionalis*) suggests that this material may be derived from more than one source.

Although there is a smaller sample of fossils from Area C, a good proportion of specimens have been identified to species level with the majority of these indicative of the early Middle Pleistocene. As with the artefacts, it is likely that these specimens are derived from an unidentified exposure of the CF-bF.

## Discussion

The analysis of both the artefacts and mammalian fossils has produced interesting patterns. For the artefacts, the combination of distribution, artefact type, size and condition data suggests that two of the concentrations derive from the known sediments at Site 3 (Area A) and Site 1 (Area B). The statistically significant concentrations, however, are found around HC (Area A), Group 2 (Area B) and in Area C. While the deposits at HC are known and have been mapped, these results demonstrate a previously unrecognised area of archaeological significance that merits further archaeological investigation. The concentrations at Group 2 and Area C, on the other hand, do not correspond to mapped exposures and are more likely to derive from offshore locations, which are currently being investigated by geophysics and diver groundtruthing (Bynoe *et al.*, forthcoming).

The distribution of fossil remains is spread more widely than the artefacts throughout the three areas but still shows



**Figure 13.** Chronological spread of species recognised in this dataset. 'X' marks the only datable occurrence of this species, with dotted lines and question marks indicating uncertainty (after Azzaroli, 1996; Lister, 1996; Breda *et al.*, 2010; Lister *et al.*, 2010). Red denotes 'overlapping' species, green shows early Middle Pleistocene species and black represents Early Pleistocene species. [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

corresponding densities over the main locations, with the highest concentration occurring in Group 2 of Area B (Figures 7 and 15). A second area of lesser density occurs directly over Site 3. Despite this more even spread, and the fact that many of the specimens cannot be identified to species level, the composition of the assemblages from each of the three areas does appear to be distinct.

At the start of this paper, a simple hypothesis was proposed that littoral processes would lead to homogenised assemblages, with any patterning relating mainly to transport processes and durability. That the results show distinct, heterogeneous patterning indicates that it is revealing significant archaeological and palaeontological information. This leads to several questions: first, what are the implications of the wider dispersal of fossils, compared to the flint artefacts? Second, are there new data from the *ex situ* artefacts that can add to the interpretation of Sites 1 and 3? Finally, what are the implications of the distribution of artefacts on the foreshore for the discovery of submerged Palaeolithic sites?

### Differing distributions of fossils and artefacts

Although there are areas where fossil and flint artefact density patterns broadly overlap, particularly when looked at area by area, the overall pattern from the fossil material shows more of an even spread than that of the artefacts.

Understanding the fossil assemblage is problematic as sample sizes are small and the majority cannot be identified to species. Despite this, there are some tentative patterns for

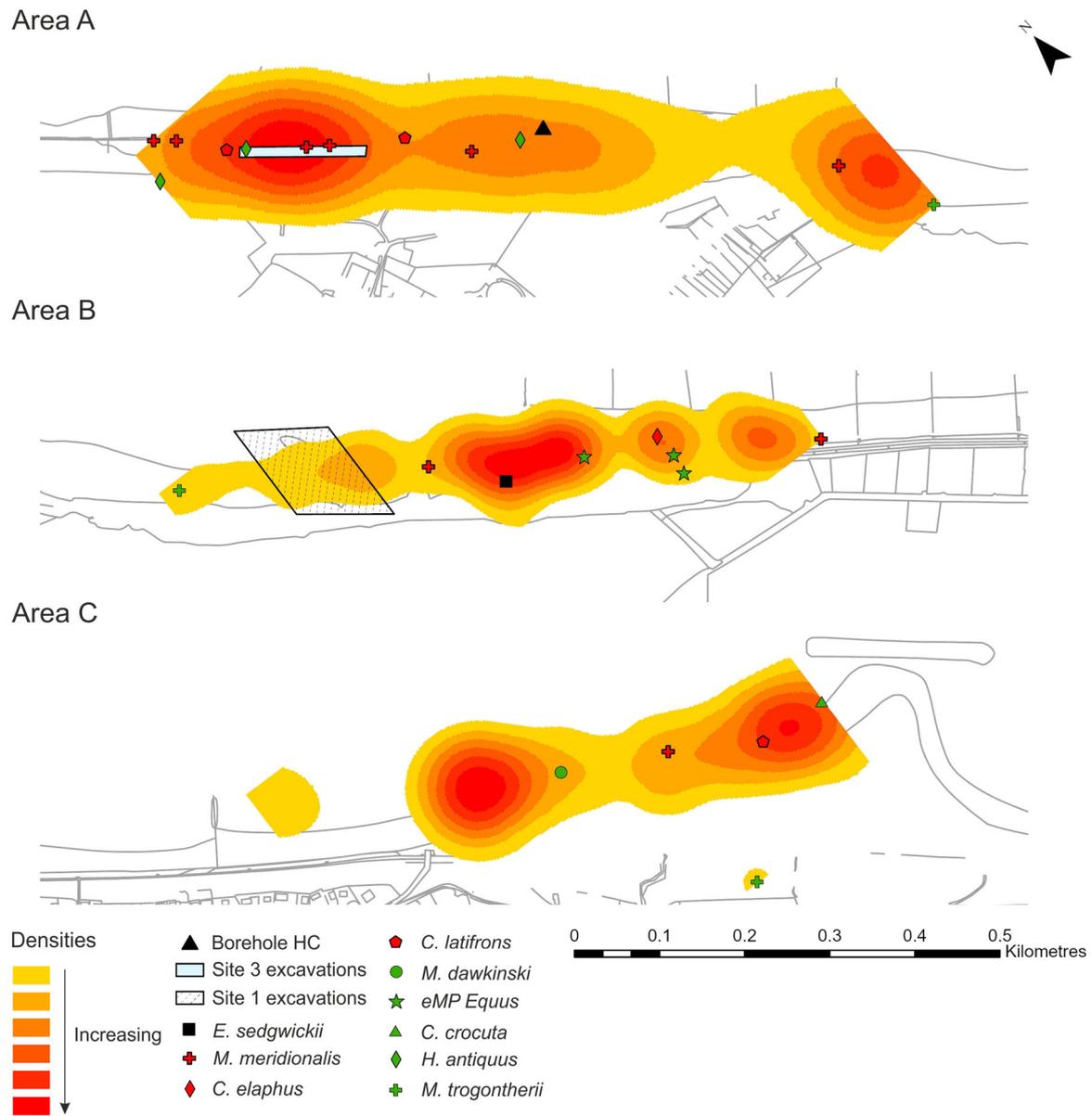
the more dispersed elements. Those recovered from Areas A and C include a greater proportion of overlapping and early Middle Pleistocene taxa respectively, suggesting that they are locally derived from source deposits of these ages. The Area B assemblage, on the other hand, has biostratigraphical indicators that suggest source deposits of both Early Pleistocene and early Middle Pleistocene age, as well as higher proportions of heavily mineralised specimens. It is suggested that the younger elements have eroded from deposits on the foreshore, such as the Low Lighthouse Member at Site 1, while the older elements have eroded from previously unrecognised deposits exposed offshore.

If it is accepted that the artefacts derive from more discrete exposures of Pleistocene deposits both onshore and possibly offshore, the patterns observed in the fossil assemblages may indicate that the fossil-bearing deposits are far more widespread, and that they span a longer period of Pleistocene time. This would support the suggestion of a punctuated human presence in the area that resulted in temporally and stratigraphically discrete concentrations of artefacts.

Considering the centuries of fossil collection documented from this coastline (Reid, 1890, 1913; Layton, 1927; Lister, 1996) the dispersed pattern of fossil finds in beach deposits and foreshore exposures is hardly surprising given the rapidity of coastal erosion and the shifting natures of the foreshore exposures of the underlying deposits. Pioneering work on the Savin collection (1942) by Lister (1996), for example, has identified clear patterns with younger, early Middle Pleistocene species being found in the cliffs or higher on the foreshore than the bulk of the Early Pleistocene specimens in areas where the contemporary deposits occur closer to, or below, the shoreline. The extent of fossil-rich deposits is further supported by the abundance of Early Pleistocene remains dredged during the 19<sup>th</sup> century from an Oyster Bed approximately three-quarters of a mile (1.2 km) off Happisburgh (Reid, 1890, 174; Lister, 1996, 34; Bynoe, 2014; Bynoe *et al.*, 2016). Significantly, our analysis of faunal remains from Area C in particular appears to indicate that offshore deposits are also yielding early Middle Pleistocene remains, including examples with cut marks. Further work is underway, both onshore and underwater, to locate and sample deposits that may be the source of the artefacts and butchered bones. The significant gap in the borehole record south of Site 1 towards Eccles North Gap contributes to a lack of information regarding deposits in this area that may be more permanently buried than those around Sites 1 and 3. Work is currently ongoing to investigate the existence of such deposits in the nearshore area (Bynoe *et al.*, forthcoming).

### Archaeology from known and unidentified sites

Beach finds of archaeological material from Sites 1 and 3 are likely to derive, at least in part, from the CF-bF deposits buried beneath the beach at these locations. This is supported by the spatial patterning of artefact condition (Figures 8 and 11), with the freshest occurring in specific zones at these sites, and increasingly abraded material occurring as transported elements in a 'trail' to the southeast in-line with sediment transport (HR Wallingford *et al.*, 2002). The significance of this interpretation is that it implies that there is a far larger archaeological resource than has previously been excavated and published (Parfitt *et al.*, 2010; Lewis *et al.*, 2019). It also suggests that foreshore exposures associated with a relatively high density of unabraded beach finds, but few isolated *in situ* artefacts (Ashton *et al.*, 2018), may contain horizons with *in situ* archaeology. Identifying such anomalies not only facilitates the targeting of high-potential deposits for investigation



**Figure 14.** Locations of fauna for each area with chronological indicators. Early Pleistocene species are shown in black, 'overlapping' species in red and early Middle Pleistocene species in green. Indeterminate species are not shown. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.com)]

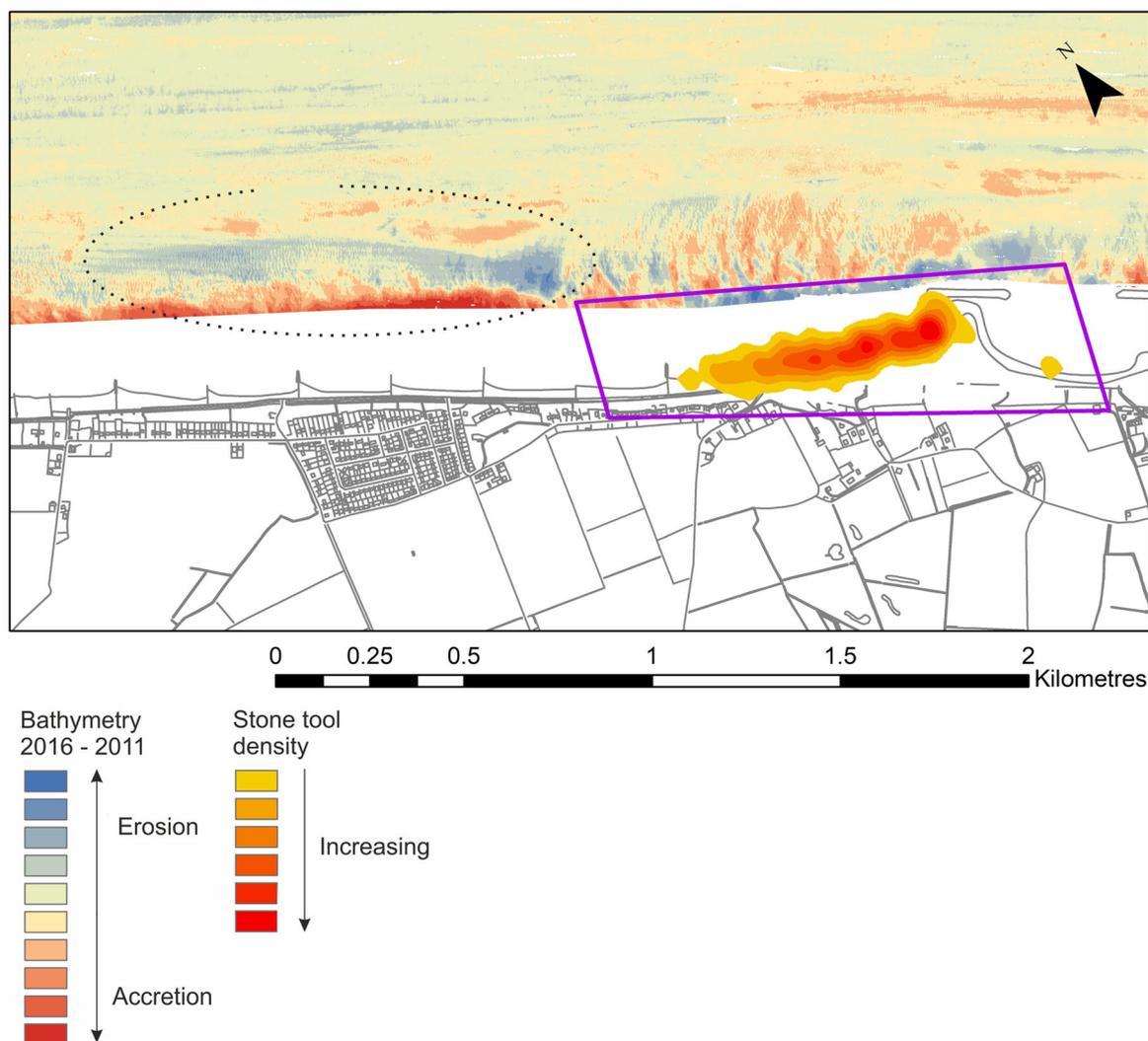
but also further highlights the value of surface beach finds for developing a framework for understanding local exposures and identifying new sites.

The presence of handaxes from the beach deposits overlying Early Pleistocene sediments at Site 3 sediments is intriguing. Although most of the artefacts in this assemblage represent a simple core and flake technology (similar to those from the *in situ* assemblage from Site 3), these are found together with unadged handaxes and a thinning flake. This raises the possibility that the handaxes also derive from the same sequence of channel deposits at Site 3. Two further handaxes found to the southeast of both the main Site 3 deposits and the HC exposure are in a more abraded condition, but could also potentially derive from Site 3 deposits.

The possibility that handaxes are a component of the Early Pleistocene artefact assemblage at Site 3 clearly needs verification through the recovery of *in situ* handaxes; it is equally possible that they derive from currently unidentified deposits of a younger date sandwiched between the Early Pleistocene sequence and the overlying glacial sediments. The recognition of an early handaxe assemblage would have important implications. Currently, the site of La Boella

(Tarragona, Spain) has handaxe technology that is associated with an Early Pleistocene fauna and attributed to c. 1 Ma to 900 ka (Vallverdú *et al.*, 2014; Mosquera *et al.*, 2015). Elsewhere in Europe la Noira (France) has well made handaxes with an age attribution to early MIS 16 (c. 676–622 ka; Moncel *et al.*, 2013, 2016), recent fieldwork at Moulin Quignon (Abbeville, France) also suggests the use of handaxe technology during MIS 16 (Antoine *et al.*, 2020) and the site of Notarchirico, Italy, has handaxes dating to c. 695 ka (MIS 17; Moncel *et al.*, 2020). All other sites from the Early Pleistocene or the first half of the early Middle Pleistocene have assemblages consisting of simple cores and flakes and lack signs of handaxe manufacture. These sites include, for example, Dmanisi (Georgia), Pirro Nord (Italy), Atapuerca and Orcé (both Spain) (Carbonell *et al.*, 1995, 2008; Azarello *et al.*, 2009, 2012; Toro-Moyano *et al.*, 2009; Mgeladze *et al.*, 2011).

Of further potential significance is the hominin responsible for the Site 3 assemblage. Currently the only recognised hominin in Western Europe at this time is *Homo antecessor*, which is associated with a core and flake industry in TD6 at Atapuerca (Carbonell *et al.*, 1995, 2008; Parfitt *et al.*, 2010).



**Figure 15.** Change in sea-bed height between 2011 and 2016, derived from Environment Agency multibeam bathymetry datasets (blue shows net erosion and red shows net accretion). The dotted oval shows the main area of net erosion, just to the north-west of Area C and the density plot shows the concentration of lithics in this area (data from Data.gov.uk). [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

If it could be conclusively demonstrated that the Site 3 deposits contained handaxes, it would fundamentally challenge our understanding of the introduction of handaxe technology into Europe, with questions about the hominin responsible, its origins and the associated behavioural and social implications.

### *The implication of onshore artefact distribution for the location of offshore sites*

The distribution and patterning of artefacts in both Area B (Group 2) and Area C imply the existence of currently unrecognised exposures of the CF-bF. With the entire coastline regularly walked and surveyed throughout the year, it is unlikely that these exposures exist on the foreshore yet have gone unnoticed. Existing borehole records in the area show no evidence of these exposures, but these are few and far-between. The more likely option, particularly given the rapid erosion of this coastline, is that these exposures are now submerged.

Group 2, the statistically significant, high density of artefacts to the southeast of Site 1 in Area B (Fig. 10), is potentially an example of this. Group 1 (those artefacts overlying the Site 1 exposures) and Group 2 display similar dimensions, although the artefacts from Group 2 are, on average, smaller and lighter, with higher levels of abrasion indicating that they have spent

more time in a higher energy environment and have probably been transported further (Table 7). As there are no known CF-bF sediments underlying this concentration, and a persistent gap in finds between the two locations, we infer that these artefacts have eroded from deposits in the nearshore zone and were subsequently transported onshore. Given that the artefacts at Site 1 were recovered from the organic-rich deposits visible onshore, as well as the underlying sands (Lewis *et al.*, 2019), it is possible that the same deposits are 'shedding' artefacts where they are eroding in a submarine setting, which are then being transported onto the beach. This would account for the higher levels of abrasion and tendency towards size sorting in this assemblage. For the time being this remains a hypothesis for testing, but the discovery of submerged exposures of CF-bF in three separate locations off Happisburgh, during diving fieldwork in 2018, makes the possibility of locating and investigating these deposits ever more likely (Bynoe *et al.*, forthcoming).

Area C presents a similar situation with the simplest explanation being that artefacts are eroding from local deposits. An immediate problem with this suggestion, however, is that there are no known local outcrops of CF-bF, the nearest being those of Site 1 in Area B, while organic deposits from Eccles, at approximately  $-0.5$  mODN, are Holocene peats (Blake 1860: 66; Lambert *et al.*, 1960; Murphy N.D.).

This raises some interesting questions about the provenance of these artefacts: if there are no local deposits, where is this large assemblage coming from, and does the nature of the assemblage provide any helpful indications?

The dimensions of the artefacts from Area C are relatively standardised, with median dimensions and interquartile ranges indicating that these may have been size-sorted to some degree (Table 2). The same pattern is true of the fossils. With the presence of the first breakwater at the southeastern extent of Area C and the resulting accretion of beach sands immediately to its northwest (Tomalla and Vincent, 2003; Phillips, 2010; Dolphin *et al.*, 2012), this area may be acting as a trap, explaining the build-up of finds in this location.

It was noted previously that the artefacts from Area C also display more patination and abrasion than in Areas A or B. Splitting the assemblage into groups based on these factors shows some immediately clear patterns (Table 8): the most rolled assemblages contain far more patinated artefacts, with just under half exhibiting some form of patination. This contrasts with less rolled artefacts, which have no patination. While it is not possible to discern what has caused this, it suggests a different taphonomic history for these assemblages.

There is therefore a discrepancy between, first, the size sorting at Area C, which indicates that the artefacts are being transported a relatively uniform distance from an unknown location and, second, the fact that the abrasion and patination on these artefacts imply differences in their taphonomic histories. A possible explanation is that this reflects differences in their time spent exposed; those more patinated and abraded pieces have spent longer caught up in the mobile beach environment.

If it is assumed that the artefacts from Area C are being transported there, then they are either eroding from known outcrops further north (i.e. Site 3 or Site 1) or eroding from an unrecognised deposit. The existence of groynes running from the south of Area B until the start of Area C (Fig. 1) makes large numbers of artefacts being transported southwards from Area B unlikely and would result in high levels of abrasion. The more probable explanation is that they are eroding from a local, but currently unknown, deposit. Given the southeasterly sediment transport direction, the lack of outcropping CF-bF deposits on the foreshore south of Site 1, and the sediment trap provided by breakwaters at Eccles North Gap, the likely source for these artefacts lies in submerged outcrops of CF-bF east, or south-east, of Happisburgh to Eccles North Gap. Indications of punctuated periods of exposure and erosion with subsequent burial of these outcrops is hinted at in two ways: first, the differing taphonomic histories of these artefacts (they were not washed up in a single event), and second, since 2017 and the end of the period of collection considered here, recovery of artefacts at Eccles North Gap has ceased. Additionally,

**Table 8.** Patination of flakes in Area C shown separated by abrasion classes.

Abrasion	Patination						Total
	0		1		2		
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
1	6	100	0	0	0	0	6
1/2	40	100	0	0	0	0	40
2	173	100	0	0	0	0	173
2/3	164	95	8	5	0	0	172
3	48	59	33	40	1	1	82
Total	431	100	41	100	1	100	473

anecdotal evidence indicates that, prior to the collecting period documented here, mammalian remains were similarly rare, while for several years before that early Middle Pleistocene mammalian fossil finds were common (S. Parfitt, unpublished data). It is possible that this temporal patterning relates to mobile sand waves periodically exposing and covering an area, or areas, of archaeological deposits in the nearshore zone.

The lack of subsurface geological data in this area makes it impossible to test this interpretation, but analysis of time-step bathymetry for the area from 2011 to 2016 does indicate an area of net sediment loss offshore of Area C (Fig. 15). If artefacts are eroding out of deposits within this location and being transported onshore, this could explain the size sorting of the material as well as the lack of extreme abrasion that might be assumed if they were moving from further afield. The presence of Site 1 deposits on the foreshore, as well as their potential continuation underwater off Area B, as indicated by recent diver ground-truthing (Bynoe *et al.*, forthcoming), could also provide another option if the submerged deposits are far enough offshore to limit the potential for the artefacts to be caught up in the Happisburgh–Eccles groynes. However, these submerged deposits seem better placed as a source of the Area B artefacts. A better understanding of the expected abrasion that movement in the marine zone may produce over a given timescale would be a good way to test these hypotheses. Diving work and marine geophysics is also ongoing in this area in an attempt to identify possible source deposits (Bynoe *et al.*, forthcoming).

## Conclusions

*Ex situ* artefacts form a significant part of the Palaeolithic archaeological record but extracting information from them is far from straightforward. Previous research has, for example, focused on the use of secondary context stone tools in fluvial archives to address bigger questions about the presence and absence of hominins through time (e.g. Ashton and Lewis, 2002; Hosfield *et al.*, 2007; Ashton *et al.*, 2011), as well as the use of surface scatters or ‘off-site’ archaeology. Once viewed with skepticism the use of this material is now well accepted, with the importance of *ex situ* artefacts making its way into curatorial guidance (e.g. Curating the Palaeolithic; Hosfield *et al.* forthcoming). Coastal finds such as those described above, however, fall into an even more problematic category as, in contrast to artefacts excavated from secondary contexts in river terraces, interpreting these finds is compounded by an additional stage of transport and sorting in a dynamic beach environment.

Our analysis of artefacts and fossils recovered from the coastline at Happisburgh has demonstrated for the first time that combining detailed distribution records, considerations of find categories (artefact type and species composition) together with preservation types and mineralisation can provide a great deal of information about the location and nature of Palaeolithic deposits.

The possible source of some of these finds from submerged deposits, combined with the ongoing work to locate and ground-truth their parent deposits, is a significant step forward for the discipline of submerged Pleistocene landscapes. The move away from a reliance on chance finds is an important facet of current submerged landscape research (Bailey *et al.*, 2020) and the use of this patterning has begun to direct targeted investigation of offshore deposits for the location of archaeological exposures. These have so far identified areas of *in situ* CF-bF in the near-shore area off Happisburgh; the first

instance of targeted dives successfully locating submerged Pleistocene deposits of this age (Bynoe *et al.*, forthcoming). This has the potential to not only begin providing the necessary data for assessing the environmental productivity of these now-submerged landscapes and their impact on hominin occupation at this early date, but to also provide a much-needed methodological framework for the location of sites of a similar nature.

This research also has wider potential for understanding the earliest human occupation of Europe. The deposits around Borehole HC, for example, have been highlighted as a potential source for *in situ* archaeology at a locality with organic-rich deposits and a rich source of environmental data. The associated deposits also include laminated estuarine sediments that preserve footprint surfaces elsewhere at Happisburgh. Of perhaps greater significance are the fresh-condition handaxes found in the beach at Site 3, which, if they can be traced to an *in situ* source, would transform our understanding of the introduction of handaxe technology into Europe. This is again a target for future investigation.

This is the first study of this kind, which has used foreshore finds to further our understanding of a unique and internationally significant, but rapidly eroding Early Pleistocene archaeological landscape. The inferences drawn above have provided new insights into the wider archaeological landscape associated with the earliest occupation of northern Europe and highlight the potential of *ex situ* coastal archaeology for future research.

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### Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## Abbreviations

CF-bF Cromer Forest-bed Formation  
MIS Marine Isotope Stage

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