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ORIGINAL PAPER

Terrestrial implications for the maritime geoarchaeological resource: A view from the Lower Palaeolithic

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Abstract Stone tools and faunal remains have been recovered from the English Channel and the North Sea through trawling, dredging for aggregates, channel clearance, and coring. These finds highlight the potential for a maritime Lower Palaeolithic archaeological resource. It is proposed here that any Lower Palaeolithic artefacts, faunal remains, and sediments deposited in the maritime zone during dry, low-stand phases were once (and may still be) contextually similar to their counterparts in the terrestrial Lower Palaeolithic records of north-western Europe. Given these similarities, can interpretive models and analytical frameworks developed for terrestrial archaeology be profitably applied to an assessment of the potential value of any maritime resource? The terrestrial geoarchaeological resource for the Lower Palaeolithic is dominated by artefacts and ecofacts that have been fluvially reworked. The spatio-temporal resolution of these data varies from entire river valleys and marine isotope stages to river channel gravel bar surfaces and decadal timescales, thus supporting a variety of questions and approaches. However, the structure of the terrestrial resource also highlights two fundamental limitations in current maritime knowledge that can restrict the application of terrestrial approaches to any potential maritime resource: (i) how have the repetitive transgressions and regressions of the Middle and Late Pleistocene modified the terrace landforms and sediments associated with the river systems of the English Channel and southern North Sea basins?; and (ii) do the surviving submerged terrace landforms and fluvial sedimentary deposits support robust geochronological models, as is the case with the classical terrestrial terrace sequences? This paper highlights potential approaches to these questions, and concludes that the fluvial palaeogeography, Pleistocene fossils, and potential Lower Palaeolithic artefacts of the maritime geoarchaeological resource can be profitably investigated in future as derived, low-resolution data sets, facilitating questions of colonisation, occupation, demography, and material culture.

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Introduction

The recovery of Palaeolithic stone tools and Pleistocene faunal remains from both the English Channel and the southern North Sea has a long, if rather poorly documented, history. Thousands of fossils have been collected from the southern North Sea, principally from the area between the Brown Bank and the Deep Water Channel but also from the Euro Channel approach to Rotterdam harbour (van Kolfschoten and van Essen 2004: Fig. 9.4). Much smaller numbers of Middle Palaeolithic artefacts have been identified from deposits offshore of Cherbourg (Fermanville) and Holland (Zeeland), with handaxes being recovered from the latter location and Levalloiso-Mousterian artefacts from the former (Verhart 2004: 57–59 and Fig. 7.3; Westley et al. 2004: 141). Other authors have also reviewed and discussed further material (the great majority of this being faunal remains) and the wider potential of the maritime zone (e.g. Flemming 1998, 2002; Hack 2000; Verhart 2001; Wenban-Smith 2003; Glimmerveen et al. 2004; Wessex Archaeology 2004; Westley et al. 2004; see also van Kolfschoten and van Essen 2004 for additional references).

These discoveries continue to remind archaeologists that these maritime zones were dry terrestrial landscapes for significant portions of Pleistocene (and Holocene) time. This theme has been emphasised in recent years with regard to both the Palaeolithic (e.g. White and Schreve 2000; Ashton and Lewis 2002; Westley et al. 2004) and the early Mesolithic periods (e.g. Coles 1998; Fischer 2004). Moreover, both Coles (1998: 45) and Westley et al. (2004: 5–6) have stressed the status of these zones as landscapes of occupation during their dry phases, rather than simply as landbridges facilitating the migration of people and animals, between Britain and continental Europe. In combination with recent work emphasising the fluvial palaeogeography of the Channel River and its tributaries (e.g. Antoine et al. 2003; Bates et al. 2003; Gibbard and Lautridou 2003; Lericolais et al. 2003; Reynaud et al. 2003) these studies have raised the possibility that there may be a significant Lower Palaeolithic maritime resource associated with, or derived from, fluvial deposits located under the sea-bed of the English Channel and the southern North Sea. To date however there have been no unequivocal finds of Lower Palaeolithic artefacts from these submerged areas. This paper takes the view that hominins would have been present in these ‘‘landscapes’’ during low stand phases, in light of their documented on-shore presence (e.g. Roberts et al. 1995; Tuffreau and Antoine 1995; Bosinski 1995), although it is recognised that occupation intensity may have been limited by the harsh climatic conditions associated with low sea levels at these latitudes (e.g. White and Schreve 2000). The apparent absence of maritime artefacts therefore requires explanation: issues of sampling logistics and/or bias, and deposit preservation and/or modification will be returned to below.

The presence of an archaeological resource, whether in relatively large or small quantities, presents a number of problems linked to the processes of discovery, recovery, assessment, protection, and interpretation. As some of these issues have been dealt with elsewhere (e.g. Wenban-Smith 2003; Gupta 2004), this paper is primarily concerned with the issues of assessment and interpretation. As with its terrestrial counterpart, the assessment and interpretation of a Lower Palaeolithic maritime geoarchaeological resource in a meaningful manner requires a comprehensive understanding of the processes of assemblage formation and modification. Such processes would influence both primary context sites and secondary context findspots (and potentially even tertiary context artefacts). These processes define the spatio-temporal resolution of the data (e.g. Stern 1993, 1994, 2004; Hosfield and Chambers 2005) and therefore provide guidance as to those questions which may profitably be asked of these data (e.g. Gamble 1996; Hosfield and Chambers 2004; Hosfield 2005).

The central premise of this paper argues that Lower Palaeolithic artefacts were deposited alongside fossil remains and fluvial sediments in the ‘‘dry’’ maritime zones during periods of low sea-level. This material is suggested to have been, at least initially (see comments below regarding reworking and tertiary contexts), similar in character to its terrestrial equivalents. In other words, the archaeological contexts were dominated by fluvial floodplain sediments, containing derived lithic and faunal material. These fluvial sediments were associated with the Channel River and its many tributaries, including the ‘‘off-shore’’ extensions of extinct and modern on-shore rivers such as the Solent River and the Bytham, and the Thames, Rhine, Seine and Somme (Fig. 1). This premise is grounded in the dominance of the terrestrial record by derived assemblages in fluvial sedimentary contexts (e.g. Bridgland 1994; Wymer 1999) and the contextual similarities of the records of southern Britain (e.g. Bridgland 1994; Roberts et al. 1995; Wymer 1999), northern France (e.g. Tuffreau and Antoine 1995; Tuffreau et al. 1997), and north-western Germany (e.g. Bosinski 1995). While the presence and considerable importance of the primary context components of the Lower Palaeolithic archaeological record is of course acknowledged here (e.g. Roberts and Parfitt 1998; Ashton et al. 1998), this paper is principally concerned with the secondary context component. This is in light of its extensive on-shore distribution and the probable disturbance and modification

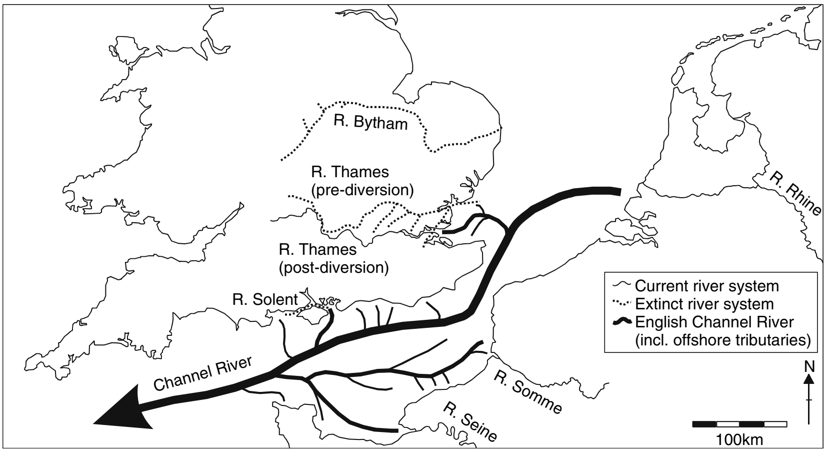

Fig. 1 The English Channel River system and selected north-west European rivers during the last glacial (after Bridgland 2001: Fig. 3.5, Bridgland and Schreve 2001: Fig. 1, Schreve and Bridgland 2002: Fig. 2, and Roberts et al. 1995: Fig. 2)

of a significant proportion of the off-shore resource (for the potential off-shore presence and detection of in situ deposits see Gupta 2004).

In light of the proposed similarities between the on-shore and off-shore elements of the secondary context Lower Palaeolithic resource, it is suggested that frameworks developed for the interpretation of terrestrial material can be profitably applied to an assessment of the interpretative potential of off-shore materials. These frameworks are reviewed briefly below.

A view from the land

The terrestrial Lower Palaeolithic resource of north-western Europe is dominated by fragmented fluvial landscapes (terrace landforms and their sedimentary deposits), containing lithic artefacts and/or faunal remains (Fig. 2). These artefacts frequently show evidence of physical damage (Fig. 3), suggestive of derived origins and fluvial transportation, as in the assemblages from Dunbridge on the River Test (Chambers 2004), Broom on the River Axe (Marshall 2001; Hosfield and Chambers 2004) and Warren Hill (Roe 1981) in East Anglia. The fluvial terrace sequences appear to have formed in response to broad and fine-scale palaeoclimatic fluctuations and isostatic and/or tectonic uplift (e.g. Vandenberghe 1995, 2002, 2003; Bridgland 2000; Maddy and Bridgland 2000; Maddy et al. 2001; Antoine et al. 2003). It is also apparent that these fluvial terrace landforms and sequences have been subjected to significant erosion over the course of Pleistocene time, through sub-aerial activity and fluvial incision and downcutting. The Lower Palaeolithic resource therefore presents a number of interpretive difficulties (Hosfield and Chambers 2004).

1. How old are the terrace sediments?
2. Over how long a period were the terrace sediments deposited?
3. Does the archaeological debris represent a chronologically homogeneous sample (i.e. is it the product of a ‘‘single’’ behavioural episode) or a time-averaged archaeological palimpsest?

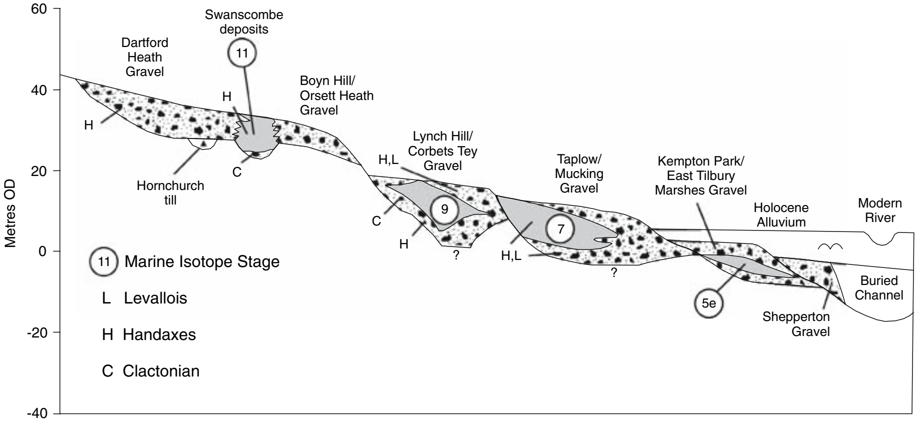

Fig. 2 Terrace landforms, sedimentary deposits and lithic artefact distributions in the Lower Thames valley (after Bridgland 1998: Figure 5.4)

Fig. 3 Sample of fluvially reworked (transported and modified) handaxes from Dunbridge, Hampshire (© Dr J.C. Chambers)

4. Is the archaeological debris the same age (or ages) as the sediments, or older (and if the latter, how much older)?
5. Did the archaeological debris originally accumulate in the landscape (e.g. through hominin tool discard and/or animal mortalities) at its place of discovery, or has it been reworked downstream and/or downslope?

All of these interpretive problems relate to the spatio-temporal resolution of the data. They are therefore fundamental to the extraction of meaningful archaeological information (e.g. spatial and chronological patterns). Much of the early work undertaken on the secondary context Lower Palaeolithic resources of north-western Europe emphasised chrono-stratigraphic dating and the identification of broad typological groupings (e.g. Breuil 1939; Breuil and Koslowski 1931, 1932, 1934; Roe 1968, 1981; Wymer 1968, 1974). To a large extent this reflected the absence of absolute dates for the fluvial terrace deposits and the need to develop broad-scale Palaeolithic chronologies. However it may in some instances have also highlighted attitudes regarding the quality of the resource and its limited usefulness.

The advent of absolute dating methods for the Middle Pleistocene saw the widespread rejection of evolutionary models of typo-technological refinement in the 1980s and early 1990s, with key evidence including the 'refined' ovate handaxes from Boxgrove at ca. 500 kya (Roberts and Parfitt 1998) and the "crude" artefacts from Pontnewydd Cave at ca. 200 kya (Green 1984). The last 15 years has also seen considerable attention paid to the secondary context resource. This has included data collation and mapping on the one hand (e.g. Wessex Archaeology 1993a, b, 1994, 1996a, b, c, 1997), and behavioural analysis and interpretation on the other. To some extent the latter has principally focused on the better contextualised material (e.g. Conway et al. 1996; White 1998a, b; Ashton et al. 1998; White et al. 2006; Ashton et al. 2006), although some studies have also utilised regional data sets including assemblages with limited provenancing (e.g. Ashton and Lewis 2002; Hosfield 2005).

During the last few years there have been major advances in optically stimulated luminescence dating (e.g. Duller et al. 1999; Agersnap-Larsen et al. 2000; Murray and Wintle 2000; Yoshida et al. 2000; Wallinga et al. 2001; Murray and Olley 2002; Toms 2002; Wallinga 2002; Bailey 2003; Bailey et al. 2003; Galbraith et al. 2005; Bateman et al. 2003; Thomsen et al. 2005) and amino-acid dating (Sykes et al. 1995; Kaufman and Manley 1998; Penkman 2005). These developments have greatly increased the potential for direct, absolute dating of fluvial terrace sediment deposits (e.g. Lewis and Maddy 1999; Hosfield and Chambers 2002; Briant et al. 2006; Toms et al. 2005). This potential for dating the terrace sequences *independently* of their archaeological content has provided an opportunity to ask an expanded range of questions of the lithic artefacts and/or faunal assemblages. However, asking such questions require archaeologists to deal with the processes of derivation, deposition and reworking outlined above: principally, the questions of how far the material has been transported and how much older than the sediments the archaeology is.

The issues of reworking have been highlighted for fluvial terrace and floodplain deposits with respect to bedrock geology and river type by Bridgland (1985) and Howard and Macklin (1999), respectively, while Hosfield (2001) has proposed models of secondary context assemblage formation. Following on from these studies, recent work by the author (see Hosfield and Chambers 2004: Ch. 7 for a full discussion of these factors) developed new models of secondary context assemblage formation and explicitly addressed the spatio-temporal resolution of the data. Five key factors were emphasised:

1. River zone type: reflecting the differential geomorphological behaviour and preservation potential of fluvial systems in their upland and lowland stretches (following Howard and Macklin 1999) it is apparent that the degree of reworking is likely to decrease markedly between the upland and perimarine/lowland zones (the latter of which are likely to be characteristic of both the Channel River and its tributaries).
2. Regional and local bedrock factors: following Bridgland (1985), Allen and Gibbard (1993) and Hosfield (2001) it is clear that even within a particular river zone (e.g. the lowland zone of the Thames Basin) terrace preservation can vary markedly, ranging from terrace flights or ''staircases'' to terrace-free ''gorges''. Such variability will again influence the potential scope for artefact reworking over relatively short (e.g. sub-MI stages) and long (e.g. multiple-MI stage) timescales. This factor highlights the importance of solid geology data in the interpretation of maritime materials, alongside Quaternary deposit and seabed sediment mapping (Long et al. 2004).
3. The three-dimensional position of assemblages within the fluvial floodplain landscape: Devensian, Lateglacial and Holocene studies of channel plan-forms, floodplains, and fluvial migration activity (e.g. Rose et al. 1980; Van Huissteden et al. 2001; Gibbard and Lewin 2002) have emphasised both the complexity of channel structures, the rapidity of change within periglacial and Holocene river systems, and the potential for rapid reworking of artefacts and sediments.
4. The timing of the initial artefact depositional events across a glacial/interglacial cycle: existing models of fluvial systems over glacial/interglacial cycles (e.g. Bridgland 2000; Maddy et al. 2001; Gibbard and Lewin 2002; Vandenberghe 1993, 1995, 2002, 2003) indicate marked variations in the nature and magnitude of fluvial activity. They also emphasise the association of fluvial activity phases with periods of climatic instability. Glacial/interglacial cycles may therefore

influence the potential scope for artefact reworking over MI and sub-MI timescales.

5. Lithic artefact condition: new experimental research by Chambers (2004, 2005a, b) and Hosfield and Chambers (2004) has indicated the development of diagnostic damage patterns resulting from fluvial transportation.

These models and variables permit the consideration of the key issues of data resolution (e.g. is an assemblage more likely to represent a 100 kyr palimpsest or a 5 kyr palimpsest? Is it more likely to have been derived from a 20 km river catchment or a 2 km catchment?). More importantly such considerations enable the explicit mapping of data scales against different analytical approaches and archaeological questions (Table 1). For example, Ashton and Lewis (2002) have utilised regional, derived artefact data from the Middle Thames fluvial landscape to track variations over time in artefact density. They used the Thames terraces as individual chronological units and the artefact data as a proxy to model possible population fluctuations. By contrast, Hosfield (2005) and Hosfield and Chambers (2004) utilised locally derived handaxes from Middle Pleistocene fluvial deposits at Broom on the River Axe (Devon/Dorset, UK) to model sub-MI stage trends in stone tool production.

The maritime resource

Having reviewed analytical models and frameworks appropriate to derived, secondary context archaeology, what is the evidence for the Lower Palaeolithic in the maritime zone? It should first be noted that large areas of the central and northern North Sea have undergone extensive glacial erosion, with these processes at least part-explaining the extremely limited resource from those regions (Westley et al. 2004: 99 and 143). However, the evidence from both the English Channel (particularly the Solent) and the southern North Sea encompass lithics, faunal material and pollen (Glimmerveen et al. 2004; Verhart 2004; van Kolfschoten and van Essen 2004; Wessex Archaeology 2004). Although the vast majority of the archaeological material that has been recovered, principally through trawler fishing, consists of

Table 1 Selected mapping of archaeological questions and approaches against variable-resolution data sets

		Chronological resolution	
		MIS (e.g. 10^{4-5} years)	MI sub-stages (e.g. 10^{3-4} years)
Spatial resolution	Regional (e.g. river valley)	Population modelling (e.g. Ashton and Lewis 2002)	
	Local (e.g. river meander)		Assemblage characterisation (e.g. Hosfield 2005); raw material procurement strategies (e.g. White 1998a); occupation histories and technological change (e.g. White and Schreve 2000)

fossil bones, this paper adopts the view that the archaeological evidence for the Lower Palaeolithic occupation of Europe incorporates both traditional lithics and palaeoenvironmental materials.

Although the exact quantities are unknown, the faunal resource is clearly very substantial. In the southern North Sea between the UK and the Netherlands for example, fossil bones have been brought ashore since at least 1874, yielding some 7,500 specimens of *Mammuthus primigenius* alone in the National Museum of Natural History at Leiden (Glimmerveen et al. 2004: 43). Drees (1986) documented 54 locations in the southern North Sea which had yielded *at least* 100 fossil bones. It is also clear that different areas of the maritime zone have yielded palaeontological remains of varying Pleistocene ages. For example, the Brown Bank and Eurogeul localities have yielded Late Pleistocene fauna (Glimmerveen et al. 2004: 44–46), while outcrops of the Yarmouth Roads Formation to the east of the Deep Water Channel have provided fossils of Early to Middle Pleistocene age (van Kolfschoten and van Essen 2004: 72–73).

The maritime faunal collections are therefore not all of Lower Palaeolithic age, and the best represented period is the Late Pleistocene [van Kolfschoten and van Essen's (2004: 75–77) terrestrial association III]. The materials most likely to be associated with lithic artefacts of Lower Palaeolithic period are van Kolfschoten and van Essen's (*ibid*: 75–77) late Early Pleistocene/early Middle Pleistocene terrestrial association II. Van Kolfschoten and van Essen (*ibid*: 76) have suggested that this association does not represent a single fauna of contemporary species, given the contrasting forest and steppe habitat preferences of two of the species (*Mammuthus meridionalis* and *Mammuthus trogontherii*, respectively). Nonetheless Cameron et al. (1984, 1989a, b) have demonstrated that only specific North Sea formations (the Yarmouth Roads Formation, the Brown Bank Formation, and the Kreftenheye Formation) yield fossil vertebrate remains, and only in those areas where these formations outcrop. The distributions of these formations should therefore provide a clear guidance to the development of sampling (and potentially protection) strategies associated with this resource. A key question however is whether further faunal associations can be identified in future which will bridge the key (from a Lower Palaeolithic perspective) chronological gap between association II (late Early/early Middle Pleistocene) and association III (Late Pleistocene). Such identifications might perhaps following the interglacial mammal assemblage zones of Schreve (2001), particularly in light of the apparent correlations between the UK and German Middle Pleistocene mammalian biostratigraphies (Schreve and Bridgland 2002). Finally, it should also be noted that association II is relatively close in age to the recently reported ca. 700 kya material from Pakefield, Suffolk (Parfitt et al. 2005; Roebroeks 2005), and that many of the species listed for this association have been recorded from the West Runton Freshwater Beds (van Kolfschoten and van Essen 2004: 77).

The evidence for lithic material of Pleistocene age in the maritime zone is far less substantial than that for the fossil bone material, but small numbers of artefacts are nonetheless present. This has been clearly demonstrated for the global Lower Palaeolithic by the recent discovery of three Acheulean handaxes in 8 m of water, in Table Bay, South Africa (Flemming 1998; Werz and Flemming 2001). With specific reference to the English Channel and southern North Sea regions, as stated earlier there are to date no clear examples of Lower Palaeolithic artefacts. There are however examples from the Middle Palaeolithic. In 1999 flint artefacts were collected from debris heaps (the product of shell-fishing close to the Dutch coast), comprising of flakes, blades, cores, handaxes and one scraper (Verhart 2001, 2004). The surface weathering of the artefacts, the nature of the lithic technology, and the presence of the handaxes were all taken as indicating a Middle Palaeolithic age for the materials. Levalloiso-Mousterian tools dating to ca. 45 kya have been found at Fermanville, Cherbourg, eroding out of peat deposits (which formed the side of a gully, interpreted as a submerged stream bed) 25 m below the surface (Westley et al. 2004: 141; Flemming 1998, 2002). Fishing activity in the Solent (Wessex Archaeology 2004) has also yielded extensive collections of lithic artefacts, of which at least some are of potential Pleistocene age, although personal observation of some of these collections by the author in 1997 suggested that the majority very probably date to the Mesolithic and Neolithic. One of the difficulties is of course the undiagnostic nature of much lithic material from the Palaeolithic period, but the Middle Palaeolithic handaxe finds do indicate the potential for the recovery and identification of Lower Palaeolithic artefacts. Moreover the increasingly robust evidence for chronologically diagnostic artefacts in the Lower Palaeolithic of the UK [including twisted ovate handaxe-dominated assemblages in MIS-11 (White 1998b) and the first appearance of Levallois technology in late MIS-9/early MIS-8 (Bridgland et al. 2006)] also offers potential for the recovery and identification of chronologically specific material.

Sediments recovered from the Eurogeul locality have also yielded pollen samples of Late Pleistocene (Weichselian) and Holocene age (Glimmerveen et al. 2004: 49–50). As with the Middle Palaeolithic lithic evidence these palynological samples certainly highlight the potential for the recovery of Lower Palaeolithic pollen material from appropriately aged Middle Pleistocene samples in the maritime zone, although no such materials have yet been recovered.

Finally, it is evident from the faunal and pollen evidence that these maritime zones were, for significant periods of the Middle Pleistocene, a potentially habitable landscape (and not simply a corridor for movement between the UK and the continent). Reconstructions of the palaeogeography of the English Channel "landscape" (Antoine et al. 2003) suggest a palaeo-landscape characterised by extensive river systems (the Channel River and its tributaries) with wide river valleys and floodplains. Such habitats may well have been attractive to Middle Pleistocene hominins, despite the colder climates associated with low sea levels, and their place within the Lower Palaeolithic landscapes of north-western Europe is worthy of greater consideration.

The maritime resource: gaps in our knowledge?

Yet how should any potential Lower Palaeolithic maritime zone resource be interpreted? The likely nature of the resource (secondary or even tertiary context assemblages, distributed over an extensive spatial and chronological range) and the current methods of recovery and collection (coarse-grained sampling through dredging) will always produce an archaeological palimpsest, of relatively low spatio-temporal resolution. Such a resource is certainly challenging, yet I suggest that the types of models and approaches described earlier above can be applied to the interpretation of the secondary (if not always the tertiary) context material. This is principally because those models make an explicit link between the questions being asked and the data scales and resolutions that characterise the data (Tables 1, 2). An immediate comparison can be made for example between the spatial scales of the Middle Thames fluvial landscape (the basis of the Ashton and Lewis (2002) model) and identified dredging areas in the English Channel and the southern North Sea (Fig. 4). The dredging areas to the immediate east of the Isle of Wight provide multiple sub-regional sampling units for exploring the archaeological signatures of the off-shore Solent River. Such comparisons implicitly acknowledge the spatial limitations of data provenancing with regard to dredged artefact material, but also highlight the value of questions addressing regional patterns in spatial palimpsest data sets. These questions can for example explore inter-regional comparisons of artefact data in terms of types and/or quantities of material.

However, exploring these types of applications and approaches also highlights two major gaps and limitations in current knowledge.

Maritime terraces?

First, investigations into the nature of fluvial terrace formation in the maritime zone and the impacts that the repeated transgressions/regressions of the Middle Pleistocene have had upon those terrace landforms and sediments are by no means complete. Two questions are particularly critical with regards to the geoarchaeological resource:

1. Do Middle Pleistocene terrace landforms and their associated deposits survive with their sedimentary architecture at least partially unmodified, or has everything been reworked into new fluvial architectural elements dating to more recent low sea-level stand events (e.g. the Last Glacial Maximum at ca. 18,000 years ago)? Such reworking was reviewed by Westley et al. (2004: 93) with regards to the potential for tertiary contexts in the maritime record. These were defined as secondary contexts formed in a terrestrial environment which had subsequently been modified and reworked during and after transgressive episodes. It was concluded that since multiple transgressive episodes have occurred over the course of the Pleistocene there is clearly potential for significant reworking of what were originally secondary context assemblages (see Westley et al. *ibid*: 176–195 for further details, including issues of sediment erosion, transport, and deposition). Westley et al. (*ibid*.) also noted that although the south coast of England is characterised by uplift activity, a key factor in terrace formation and evidenced both by the Solent River terraces and the Sussex raised beach sequence (e.g. Allen and Gibbard 1993; Bates et al. 1997; Bridgland

Table 2 Selected mapping of potential archaeological questions and approaches against variable-resolution data sets for a maritime Lower Palaeolithic resource

		Chronological resolution	
		Multiple-MIS (e.g. $10^{5–6}$ years)	MIS (e.g. $10^{4–5}$ years)
Spatial resolution	Multi-regional (e.g. southern North Sea)	Presence/absence	Occupation intensity; typological patterning
	Regional (e.g. dredging sampling areas)	Presence/absence; regional variations	Population trends; typological patterning

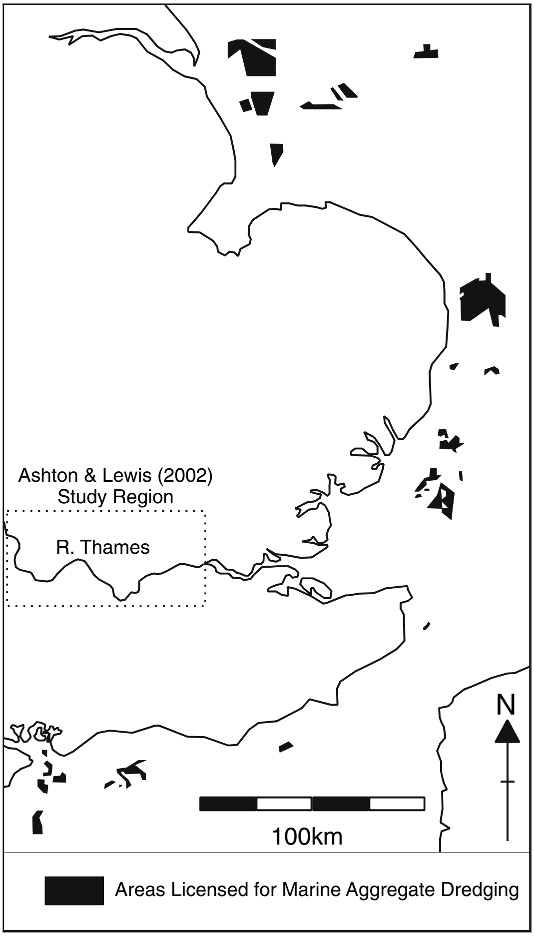

Fig. 4 Spatial scales of licensed marine aggregates deposits (after Wenban-Smith 2003: Fig. 1) in the English Channel and southern North Sea, and Ashton and Lewis' (2002: Fig. 1) Middle Thames study region

2001; Bates 2001), investigations to date have produced relatively little evidence for river terraces within the English Channel sediments. They suggest that this paucity is most pronounced in the larger palaeovalleys such as the Lobourg Channel and the Northern Palaeovalley (Westley et al. 2004: 135). This has been attributed by Hamblin et al. (1992) to destruction and reworking during subsequent high sea level transgressions. In other areas however net subsidence resulting in stacked sequences of deposits (decreasing in age upwards) may explain the absence of terrace landforms and their deposits (Bridgland 2000: 1297).

However, other work on both sides of the English Channel and from the southern North Sea suggests that in places there *are* preserved landforms and deposits of Pleistocene age. Antoine et al. (2003) have mapped the large palaeovalley of the Seine, with its stepped terraces, beneath the modern Channel. Bellamy (1995) has recorded cold and warm stage terrace deposits and an infilled valley complex representing the offshore extensions of the River Arun and spanning at least three climatic cycles (see also Bridgland 2002: 27). Aggradations of a pre-Holocene interglacial, probably the Ipswichian, were recorded, along with both preceding and subsequent cold stage gravel aggradations and overlying Holocene estuarine sediments. Offshore buried channels have also been recognised in the East Solent (Velegrakis et al. 1999), while in the North Sea region, the British Geological Survey (Cameron et al. 1984, 1989a, b) have mapped a series of formations of Pleistocene age. Indeed Cameron et al. (1992) have suggested that with the exception of the gravel waves between the South Falls and the Sandettie Banks, the majority of the Pleistocene fluvial (and glacial) gravel deposits in the southern North Sea have not been reworked to a significant degree, despite the presence of strong tidal currents. From a Lower Palaeolithic archaeology perspective therefore, there appears to be some evidence for preserved Middle Pleistocene terrace deposits. It is stressed however that in many instances the degree of erosion is poorly known and the geochronological controls are poor in comparison to the current terrestrial situation.

Two approaches are suggested here as starting points for accessing these issues. First, the application of optically stimulated luminescence dating to surviving fluvial sediments. This has been demonstrated by Stokes et al. (2003) for Late Pleistocene sediments, and adopted recently by Wessex Archaeology (Firth pers. comm.), although their preliminary results were unsatisfactory. Second, evaluating the physical condition of dredged artefacts. Chambers (2004, 2005a, b) has proposed that fluvially transported handaxes display diagnostic patterns of damage. If artefacts reworked on the sea-bed (as a result of transgression/regression events) display different (non-fluvial) diagnostic damage patterns, then physical condition could be used as a partial indicator of taphonomic history. For example whether the dredged artefacts were recovered from preserved Middle Pleistocene-age terraces (showing fluvial-type damage signatures) or from ‘‘modern’’ reworked sediments (in which case marine-type damage signatures would be expected). This approach obviously requires programmes of experimental work, and results could also be evaluated against the material collected from sites such as Rainbow Bar, Hill Head in the Solent (e.g. Roe 2001; Hack 2000), where flake and core artefacts of variable status have been subjected to both fluvial and marine modification. Such work should also be integrated with current understanding of marine taphonomic processes, principally sediment dynamics. These processes have clear implications for the distribution (including the degree of ‘‘patchiness’’ and size sorting) of reworked archaeological material (see Westley et al. 2004: 176–195 for a review).

2. Even if Middle Pleistocene terraces and sediments are preserved however, is there evidence for classical terrace staircase sequences? As illustrated for example in the terrestrial extents of the Thames and Somme valleys (e.g. Breuil 1939; Bridgland 1994; Bridgland et al. 2004), such sequences are increasingly providing the basis for robust, geochronological models (e.g. Bridgland et al. 2006). As discussed above there is evidence for stepped terraces in the offshore palaeovalley of the Seine (Antoine et al. 2003). Similarly, Durrance (1969, 1974) has documented distinct river terrace sequences associated with the Teign estuary (at –10.0 m, –14.0 m and –23.0 m) and the modern Exe estuary (at –5.8 m, –10.4 m, –14.0 m and –22.0 m) in the UK. Dyer (1975) reported a series of terraces in the Solent, while D’Olier mapped a series of submerged Thames terraces in the southern North Sea (Bridgland 2002: 29–30).

Perhaps unsurprisingly (reflecting relatively shallow water depths and the locations of seismic profiling surveys and coring) many of these terrace sequences have been documented in the immediate offshore areas. In these areas they are typically associated with the buried channel extensions of estuarine lower reaches of modern rivers. Moreover, it seems extremely likely that in different regions of the non-glaciated maritime zone (i.e. the English Channel and the southern North Sea), terrace development varied in pattern and extent, reflecting marine influences and uplift rate differences. Antoine et al. (2003: 240) noted the major changes in the bedrock gradient profiles between the lower Somme and the submarine area, and suggested that these were the result of differential uplift rates. While the relatively high rates in the lower valley are associated with a stepped terrace system and high gradients, the lower uplift rates and ‘‘relative subsidence’’ in the submerged area are linked with stacked alluvial sequences and a lower gradient. Bridgland (2002: 30 and Fig. 5) has also reviewed similar evidence for the Rhine system.

Vertical, stepped terrace sequences with altitudinally separated units would offer potential for long profile correlations with the terrestrial terraces (e.g. Bridgland 2002: Fig. 3). Their absence in particular parts of the maritime zone therefore creates obvious difficulties for the development of robust geochronologies (whether absolute or relative), even before considering the potential problems of lateral reworking. There is clearly a need for further studies highlighting both the nature of, and potential for, long-term terrace development in the southern North Sea and English Channel zones, and the development of direct OSL dating of submerged deposits.

In summary then, there is a clear need to assess, on an area by area basis for the maritime zone, first whether terrace deposits would actually have formed, and second whether they would have subsequently been preserved over the long time-span of the Middle and Late Pleistocene (after Westley et al. 2004: 136).

Sampling problems

Second, how will any Lower Palaeolithic resource be sampled from the maritime zone? It is apparent that the only practical collecting and sampling strategies at the current time are those developed through collaboration with the fishing industry (Glimmerveen et al. 2004; Verhart 2004; van Kolfschoten and van Essen 2004), aggregates companies (Flemming 2004), and dredging operations relating to the maintenance of navigation routes (van Kolfschoten and van Essen 2004). Current information regarding the location and context of material is often limited and of relatively poor spatial resolution, although in some instances (e.g. Glimmerveen et al. 2004; Mol et al. 2003) GPS co-ordinates have provided exact localities for retrieved materials. Overall these sampling activities are clearly broad-scale, and it appears likely that they will remain so for the foreseeable future. It is perhaps worth noting here however that evaluation of areas of archaeological potential (maybe based on previous fossil finds and/or the location of key sedimentary deposits) could potentially utilise a logistic dredging approach, in advance of commercial dredging activities. Samples could then be specifically examined for possible archaeological content.

In the meantime the current, broad-scale sampling strategies have clear implications for data quality and the identification of interpretative models and potential questions. Yet as indicated above such sampling strategies and collection activities can be integrated with a palimpsest data resource and appropriate-scale methodologies to potentially extract valuable archaeological data. As discussed throughout this paper, the first requirement is to consider the potential spatial and temporal scales of the available data and how it may be related to appropriate questions. It is apparent from the above discussions that data from particular regions is likely to be both heavily time- and space-averaged. This reflects fluvial reworking of artefacts during low sea-level stands, possible marine reworking of sediments and artefacts during the high sea-level stands (i.e. the transformation from secondary to tertiary contexts), and the nature of the current sampling strategies. Nonetheless, two potential data patterns are suggested here as initial foci for future research questions (Table 2).

- Variations between river systems (e.g. the offshore Arun or Seine) and/or regions (e.g. the southern North Sea and the central English Channel) in terms of quantities of material culture. These patterns could be valuably related to onshore regional patterns (e.g. differences in material quantities between the Thames Valley and the Solent River Basin, or the Somme and the Rhine Valleys) to consider wider-scale questions of hominin colonisation patterns in north-western Europe during the Lower Palaeolithic.
- Variations between river systems and/or regions in terms of variations in material culture. For example testing the apparent claims by White and Schreve (2000: 15–20) that Acheulean (handaxe) groups may have entered Britain from northern France, while Clactonian (core and flake technology) groups may have entered Britain from Germany and central Europe.
- It is also worth considering that appropriately large-scale questions might even highlight archaeological potential in the reworked tertiary context resource. This would obviously be of greater likelihood if any resources were located in the vicinity of the secondary contexts from which the sediments were reworked (Westley et al. 2004: 144).

Conclusions

In conclusion, the extensive faunal material and much more limited lithic artefact archive from the southern North Sea and the English Channel, combined with other recent research, has begun to promote the idea of a Palaeolithic archaeological potential for the maritime zone in north-western Europe. Indications from very occasional artefact finds and inshore mapping suggest that Pleistocene fluvial terraces may extend offshore in places. Moreover, the terrestrial Lower Palaeolithic record for north-western Europe indicates to us that despite data reworking there is still valuable evidence in the secondary context archaeological resources of fluvial landscapes. It is therefore suggested here that offshore terraces may be amenable to an application of assessment and analytical frameworks similar to those applied to terrestrial deposits. Equally however, it is clear that to fully access these data there is a need for robust geochronological and geoarchaeological models and appropriate mapping of archaeological questions against the variable spatio-temporal scales. Of particular importance is the need to:

- Understand the geoarchaeological processes associated with terrace landform and deposit formation and modification in the maritime zone.
- Develop appropriate deposit (as opposed to site-based) modelling (Westley et al. 2004: 206) and archaeological sampling and dating strategies.

But by asking the right questions at the right spatio-temporal scales, we may be able to finally start to get to grips with a significant, understudied, and extensive landscape in the north-western fringes of the Acheulean world.

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