

GEOARCHAEOLOGICAL REGIONAL REVIEW OF MARINE DEPOSITS ALONG THE COASTLINE OF SOUTHERN ENGLAND

Scott Timpany



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Geoarchaeological Regional Review of Marine Deposits along the coastline of Southern England

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Geoarchaeological Regional Review of Marine Deposits along the coastline of Southern England

Scott Timpany

SUMMARY

Coastal deposition has led to the accumulation of some of the thickest deposits of Holocene sediments in the British Isles. Often permanently waterlogged, these sediments provide ideal conditions for the preservation both of archaeological remains and palaeoenvironmental material. They therefore represent a geoarchaeological resource of the highest value and have been the source of some of the most exciting archaeological discoveries of recent times.

This review aims to provide a synthesis of the location and nature of geoarchaeologically significant marine deposits around the southern English coastline and identify any areas where future work is needed. The coast continues to be a dynamic environment and the review comes at a time when the United Kingdom's coastal sediments are increasingly at risk of erosion, caused by rising sea-levels driven by climate change. The review therefore includes deposits that formed in a terrestrial environment but are now submerged as a result of a rise in relative sea-level.

KEYWORDS

Geoarchaeology
Soil/Sediment
Environmental Studies
Radiocarbon Dating

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ACKNOWLEDGEMENTS

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I. INTRODUCTION

Geoarchaeology and marine deposits

Depositional processes in the coastal zone have led to the accumulation of some of the thickest deposits of Holocene sediments in the British Isles. These sediments, often permanently waterlogged, provide ideal conditions for the preservation both of archaeological remains and palaeoenvironmental material (e.g. pollen and plant macrofossils). They therefore constitute a geoarchaeological resource of the highest value and have been the source of some of the most exciting archaeological discoveries of recent times. Just one example of this is Mesolithic human footprints found in the Severn and Mersey Estuaries (Roberts *et al* 1996; Bell 2007) (see Figure 1).



Figure 1: Mesolithic human footprints at Goldcliff East, Severn Estuary (Copyright M. Bell and Severn Estuary Levels Research Committee)

This review will emphasise that the coastal environment has been subject to major environmental change and the accumulated deposits can provide a detailed record of that environmental history. The coast continues to be a dynamic environment and this review comes at a time when the United Kingdom's coastal sediments are increasingly at risk of erosion, caused by rising sea-levels driven by climate change. It is therefore an appropriate time to review the resource and its value for geoarchaeological investigations. Studies from the late 19th and early 20th centuries (e.g. Reade 1871, Ashton 1909; Reid 1913) highlight just how much we have lost and with this loss of sediments goes the potential

for geoarchaeological study. Figure 2 shows a photograph taken at Borth, Cardigan Bay of the submerged forest as it is today. Photos taken 70 years ago (see Godwin and Newton 1938) show a far more extensive deposit. More recent work in the Severn Estuary has estimated the loss of Holocene peat deposits through tidal erosion at approximately 1m annually (Bell 2007).

The coastal location of these deposits will always leave them open to erosion from tidal and storm action, but it is this same action that has been responsible for the uncovering of archaeological finds (e.g. the Iron Age at settlement at Goldcliff East, Bell *et al* 2000), making them attractive locations for geoarchaeological investigations. Add to this the excellent preservation of organic materials in the waterlogged sediments and we have a resource of very high value. The importance of these sediments for geoarchaeological study is the underlying theme of this report, which also seeks to provide a synthesis of our current knowledge from past studies, and to highlight those areas that will benefit from future research.



Figure 2: Submerged forest at Borth, Cardigan Bay (Photo H. Guizer)

Scope of the review

For the purpose of this review marine deposits have been defined as:

All sediments currently below high tide level as well as any marine deposits formed during previous periods of higher sea-level that are currently above the tidal limit.

As a result, the review will include some deposits that formed in a terrestrial environment but are now submerged as a result of a rise in relative sea-level.

The overall aim of this report is to provide a useful synthesis of the location and nature of geoarchaeological studies of marine deposits around the southern English coastline. In order to achieve this aim a number of objectives have been set:

- To describe the different types of marine deposits
- To describe the different processes of sediment deposition
- To summarise all major geoarchaeological studies undertaken in the area
- To identify any areas where future work could be undertaken

The area of the review is the southern English coastline, which is defined as the zone from the Bristol Channel in the west round to the Thames estuary in the east (see Figure 3). This southern region can then be broadly divided into three geographical sub-regions:

1. The southwest: Gloucestershire, Somerset, Devon (north coast) and Cornwall. Sites of particular interest in this area are those in the Bristol Channel, Somerset Levels, Barnstaple Bay and the Cornish coastline.
2. The south: Devon (south coast), Dorset, Hampshire and West Sussex. Sites of particular interest here are those in the Solent, Langstone Harbour and Poole Harbour, and the pre-Holocene raised beaches of West Sussex.
3. The southeast: East Sussex, Kent, Greater London and Essex. Areas of particular interest here are Romney Marsh and the Thames Estuary.

Scope of work

There are three main sedimentary environments to take into consideration:

- 1) coastal (predominantly intertidal) environments
- 2) river valleys linked to the coast
- 3) offshore environments

It is the first of these three environments that makes up the bulk of the review with a much larger number of studies taking place in the intertidal area as opposed to offshore environments. In part this is due to the accessibility of these sites as only more recently, with advances in equipment and techniques, has more detailed work become possible offshore. However, the studies undertaken on such sites have already proved extremely valuable (e.g. Bell 2007). This theme is returned to in Section 5.

In order to compile this review, information was drawn from a number of sources with published literature forming the largest body of data. The other main source utilised was unpublished reports (grey literature) from both archaeological companies and research institutions. In addition, Dr Zoë Hazell of English Heritage provided access to her database on peat deposits from this section of the English coastline, which proved to be an invaluable tool in seeking out published work (see <http://www.english-heritage.org.uk/server/show/ConWebDoc.15209> and Hazell 2008). Special mention must be made to the remarkable publication of Professor John Allen (2005) on the Holocene deposits of the south, which is a key reference for this review.



Figure 3: Study area of the report

Periods covered by the review

The periods of interest within this review can be separated into two: Holocene and pre-Holocene.

Pre-Holocene deposits, which are discussed in Section 3, are largely of Pleistocene date, up to two million years old. The majority of the evidence for this period comes from sediments currently above the tidal limit, deposited at a time when sea-level was higher than it is today. The bulk of this review deals with Holocene deposits (Chapter 4), which are not more than 10,000 years old. These deposits are currently at or below the present high-tide limit. Table 1 shows the time periods likely to be encountered in this report.

Table 1: Time periods which may be mentioned in the review

Period	Epoch	Glacial/Temperate period	Time BP
Holocene (Flandrian)	Holocene	Temperate	10,000 to present
Upper Pleistocene	Devensian (Weichselian)	Glacial	
	Ipswichian (Eemian)	Temperate	
	Wolstonian (Saalian)	Glacial	
Middle Pleistocene	Hoxnian (Holsteinian)	Temperate	
	Anglian (Elsterian)	Glacial	
	Cromerian	Temperate	c. 350,000
	Beestonian	Glacial	
	Pastonian	Temperate	
Lower Pleistocene	Baventian	Glacial	c. 500,000
	Antian	Temperate	
	Thumian	Glacial	
	Ludhamian	Temperate	
	Pre-Ludhamian		c. 2,000,000

All radiocarbon dates mentioned in the text are from deposits within the sequences themselves rather than archaeological material, which may have an uncertain taphonomy. All dates are presented in calibrated years BC and have been calibrated using OxCal version 3.10 (Bronk Ramsay 2005) to 95.4% probability.

What this report is not intended to achieve

The report is intended as a synthesis of geoarchaeological work, including both palaeoenvironmental and stratigraphic investigations. The report will not contain detailed information on any individual site or study; rather it will be directing the reader to the work that has been done and briefly reviewing this. Key references are given throughout Sections 2, 3 and 4 and these, together with the bibliography, should enable the reader to follow up on any specific sites or studies of interest.

How the report is laid out

The report contains four sections, in addition to this Introduction. Section 2 contains a summary of the various types of sediment encountered in the marine environment and the processes of deposition leading to their formation. Readers familiar with this material may wish to turn immediately to Sections 3 and 4, which contain the main data review (pre-Holocene and Holocene respectively). In both of these sections the review has been divided into three geographical areas: southwest, south and southeast. The final Section 5 contains a discussion of the work summarised in Sections 3 and 4, focussing on common themes that emerge from the data. It addresses the geoarchaeological potential of the

deposits and prospects for future work. It also highlights current and future threats to the resource.

2. SEDIMENT TYPES AND FORMATION PROCESSES

Sediment types

A variety of sediment types make up the pre-Holocene and Holocene deposits observed around the southern English coastline. These sediments often include gravel and sand but more frequently are intercalated sequences of silts and peats, the latter representing the most intensively studied type of sediment (Allen 2005). These two main sediment types are described below.

Estuarine silts

Estuarine silts are minerogenic sediments held in suspension and deposited by tidal waters. They can include quartz, clay minerals and detrital/diagenic carbonate together with some plant matter. Deposition is largely below the level of Highest Astronomical Tide (HAT), with pre-Holocene deposits found at higher altitudes due to former sea-level being higher than that of today.

The way these silts are sorted can also inform us on how they were deposited in the past. If the silts are well sorted (e.g. all grains are of a similar size) then we can infer that they were laid down in a stable environment or one of gradual change (e.g. slow rate of sea-level change). However, if the silts are poorly sorted (e.g. grains are of differing sizes) we can infer the opposite, that the silts were deposited in a period of rapidly changing conditions and/or high-energy events (e.g. a storm surge).

Allen (1990) notes that today's tidal waters are often very turbulent, carrying high yields of silt for deposition within intertidal areas. He suggests that the turbidity of these waters has increased with time, caused by increases in the tidal range and deforestation of areas within the catchment (e.g. from agricultural activity), which has promoted mineral erosion.

Peats

Peats are accumulations of organic plant matter (detritus), which form in waterlogged locations. Here the breakdown of plant matter such as leaves, roots and stems together with dead wood and bark fragments is slowed due to anaerobic conditions (absence of oxygen). The anaerobic conditions of the peat help to preserve the plant materials, as without oxygen bacteria cannot survive to break down the plant matter. These plant remains can then be investigated through palaeoenvironmental techniques including pollen and plant macrofossil analyses. Insect remains will also be preserved in peat and their analysis can provide information on former environments.

In the past, peats would have formed a significant contribution to sediment deposition, with salt marsh, reed swamp and wet woodlands all present along the southern coast at

varying times. Buried soils or old ground surfaces can be found where plant matter has accumulated within deposits to form what once would have been a stable ground surface.

Allen (2005) observes that peat layers across locations along the southern coastline can be present at multiple points within a stratigraphy and can vary greatly in thickness and depth. The places where such peat layers occur within sequences are regarded as periods of stability, where plant detritus can accumulate above the level of sea-level rise. He has termed such events "punctuation periods", where there is a slowing down in the level of sea-level rise and thus deposition of mineral material is punctuated by layers of peat.

The peat layers themselves can be grouped into different types through palaeoenvironmental analysis of the plant remains preserved within them. There are broadly three types of peat recognised:

1. Wood peat - laid down during periods when woodland was present on the peat surface. It contains wood fragments (and on occasion stumps and trunks: "submerged forests") of carr woodland species such as alder, birch and willow.
2. Fen peat – deposited during periods when reed swamp was present. This contains fragments of monocotyledon plant tissue from herbaceous taxa such as grasses (e.g. reeds) and sedges.
3. Raised mire peat – formed during periods of raised bog growth. These peats contain fragments of heather and other bog indicator species, reflecting the acidic nature of the peat.

Landscape evolution can be witnessed through the different peat deposits, and palaeoenvironmental study of these deposits has revealed a general sequence of succession from fen peats to wood peats back to fen peats and then to raised mire. This sequence has been identified at a number of study sites in coastal locations such as the Severn Estuary (e.g. Smith and Morgan 1989; Walker *et al* 1998; Timpany 2005; Bell 2007), Southampton Water (e.g. Long *et al* 2000) and Romney Marsh (e.g. Long *et al* 1998; Waller *et al* 1999). This sequence demonstrates the colonisation of open water areas by vegetation, which eventually become changed into terrestrial surfaces. However, as the rate of sea-level rise increases above the rate of peat formation these areas become drowned landscapes, submerged by the tide. In stratigraphic columns, this is shown by layers of silt overlying the peat, marking the end of that punctuation episode and a change in the dominant sediment deposition from endogenous to exogenous sources.

In some locations drowned landscapes can still be seen today, often being described as "submerged forests" (e.g. Campbell and Baxter 1979). These former woodlands are one of the most enigmatic sights in coastal locations. They have long been imbued with a sense of mystique (e.g. Reade 1871, Ashton 1909 and Travis 1926) and have even been linked with lost lands (Godwin 1981; Johnson and David 1982). Today they are being increasingly studied in order to provide geoarchaeological information on what the coastline would previously have looked like (e.g. Timpany 2003, 2005), as well as being relevant to sea-level studies (e.g. Kidson and Heyworth 1973; Campbell and Baxter 1979).

Other sediments

Other sediments mentioned in the text, particularly in the pre-Holocene deposits, and worthy of note here are sands and gravels. Sands, like silts can be deposited from suspension in tidal waters but can also accumulate through wind transport. For more information on aeolian sand, please refer to the review of windblown deposits (Brown and Bell 2008). Gravels are much larger particles than silts and sands and thus are generally deposited by high-energy tidal systems and events (e.g. tidal waves, see below). As with silts, the sorting of both sand and gravel can inform us on how they were deposited.

Factors affecting sediment deposition

Sea-level change

The deposition of sediments in coastal locations is invariably linked to rates of sea-level change. Episodes of peat deposition in such locations are dependent on slow sea-level rise, whereas deposition of minerogenic material such as silts and clays are reliant on tidal driven mechanisms (e.g. suspension). As Allen (2005) highlights periods of mean sea-level (MSL) rise may be responses to global changes in sea-level, which can affect the coast at the regional and local level.

Peats in particular have often been used as sources of sea-level information due to their recognition as punctuation events, marking out periods where sea-level was below the peat surface. The plant material they contain can then be radiocarbon dated to give a known point in time for the former position of the sea-level. By dating multiple peat horizons throughout the stratigraphy it is sometimes possible to produce a sea-level curve, which charts the rate of sea-level change for a given area (e.g. Kidson and Heyworth 1978; Akeroyd 1972).

Vertical crustal movements

Another control on sediment deposition on medium and long timescales is the gradual vertical movement of the Earth's crust. This action is occurring across the south of England as a response to past ice loading/unloading during successive glacial and interglacial periods (glacio-hydro-isostasy). In locations covered by glaciers during the most recent (Devensian) glacial period, the Earth's crust is rising as it rebounds from the weight of the ice. However, in surrounding areas, the reverse is taking place and the Earth's crust is sinking as it maintains equilibrium with those areas which are rising. Southern England, which was not covered by ice during the Devensian, is thus currently sinking. Shennan and Horton (2002) have reported that present day rates of crustal movement for the south at c. 0.5-1 mm/yr, the larger values typifying areas such as the Thames Estuary, the outer Bristol Channel and Cornish peninsula (Shennan and Horton 2002; Allen 2005).

The rate of crustal movement over time affects the rate of mean sea-level rise in these locations and hence sediment deposition. Through looking at reconstructed sea-level curves from peat information, the effects of crustal movement and mean sea-level rise can

be deduced. Allen (2005) shows that, during the early Holocene, sea-level rose in the Bristol Channel-Severn Estuary area by 10mm/yr but that this gradually slowed to around 1mm/yr by the later part of the period. However, this rate has begun to accelerate significantly during the last 150 years due to the effects of global warming (Gehrels *et al* 2005).

Sediment supply

The two main types of sediment (organic and mineral) have already been described above and are revisited here briefly to look at factors affecting supply rates. The organic sediments are largely reliant on in situ plant growth to contribute a large biomass to sediment formation. In the past this supply has occurred at different rates as vegetation changes; for example carr woodlands would have provided a large amount of biomass, which is seen in the significant depths of wood peat. Current saltmarsh landscapes vary in their ability to supply quantities of biomass, with rates being dependent on a number of factors, such as climate, species, tidal inundation and distance to the marsh edge (Allen, 2005). Use of these areas for grazing has also contributed to a decrease in the level of biomass available for deposition. Such activities are known to have taken place in coastal locations since prehistoric times (e.g. Bell *et al* 2000).

The mineral sediment supply is controlled by the amount of suspended sediment being held by tidal waters. This can be measured by the degree of turbidity of these waters; the higher the turbidity the larger the sediment yields of the waters and the higher the rate of sediment deposition. The level of turbidity is dependent on a number of factors, which include tidal stirring, variation in tidal range, fluvial supply and areas resistant to erosion. Increasing levels of soil erosion within a catchment can also cause an increase in turbidity, which must have occurred in the past as catchments were deforested to make land available for agriculture (Allen 2005).

Compaction

As with the crustal movement discussed above, the sediments themselves can also be affected by loading, but here it is their own weight causing the sediments to compact and thus undergo some vertical movement, rather than the effects of glaciation (Allen 2005; Edwards 2006; Long *et al* 2006). Peats, in particular, are extremely prone to compaction, being largely soft with the exception of large wood fragments (e.g. Long *et al* 2006). The effect of compaction is felt by the entire stratigraphic sequence and causes the active depositional surface to subside, while simultaneously reducing the altitude of all the stratigraphic layers below (Allen 2005). Sediment supply can then be affected if compaction causes the active deposition surface to fall below the level of MSL.

Decalcification

Similar to compaction, decalcification can affect the height of the stratigraphic column and thus the thickness of the deposits. The process involves the loss of carbonate detritus present in silts through the actions of acid waters. Where such carbonate matter makes up a significant element of that silt layer there can be a considerable subsidence. In the Severn Estuary, for example Allen (1987) notes that such carbonate matter forms 10-15%

of the silt layers. Loss of this component will result in the vertical movement of the active deposition surface.

Table 2: Summary of factors that control punctuation in Holocene coastal sequences (Allen 2005, p26).

Factor and scope	Rate/quality of influence	
	low	high
mean sea level (regional, rate +ve)	promotes high intertidal marshes	Promotes low intertidal marshes and mudflats
mean sea level (regional, rate -ve)	promotes soils/some supratidal marshes	promotes supratidal marshes, but may constrain the latter through the effect on water-table
vertical crustal movement (regional rate variously -ve in southern Britain)	promotes high intertidal marshes	promotes low intertidal marshes and mudflats
changing tidal range (local, rate +ve)	promotes high intertidal marshes	promotes low intertidal marshes and mudflats
changing tidal range (local, rate --ve)	promotes soils/some supratidal marshes	promotes supratidal marshes, but may constrain the latter through the effect on water-table
exogenous sediment supply (local-district, rate +ve)	promotes low intertidal marshes and mudflats	promotes high intertidal marshes
endogenous sediment supply (local-district, rate +ve)	promotes minerogenic intertidal marshes	promotes organogenic high intertidal and supratidal marshes
Surface subsidence due to compaction (local, rate -ve)	promotes high intertidal marshes/soils/some supratidal marshes	promotes low intertidal marshes and mudflats
marsh-edge retreat followed by advance (local to district scale)	leads to the partial elimination of prior silt and peat beds, and the development of erosional hiatuses succeeded by renewed mudflat-salt marsh deposition and the eventual possibility of further peatland	
coastal barrier development (district scale)	substitutes sandy-gravelly for silt-peat facies, with migration of barriers islands and inter-island tidal channels eliminating prior silt-peat sequences and creating hiatuses	

Coastal change

The changing nature of coastal areas has an effect on rates of sediment deposition and this factor has varied in importance through time as coastal landscapes changed in response to rising MSL. For example, the development of gravel barriers and sand bars can affect the rate of sediment deposition. Allen (2005) notes that during rise in MSL the expanse of water becomes larger as estuaries develop and coasts change from sheltered, tide-dominated to exposed, wave-dominated environments. These factors, and the others described above, have been summarised by Allen (2005) (see Table 2).

Recommended further reading on sediment types and processes of deposition can be found in Bell and Walker 1992; Ellis and Mellor 1995; Rapp and Hill 1998; Wild 1993.

3. PRE-HOLOCENE DEPOSITS

The pre-Holocene marine deposits encountered around the south coast of England are few and far between (see Figure 4). This section of the review is therefore relatively sparse in information when compared to that dealing with the Holocene deposits (Section 4). This reflects not only the large amount of literature available on Holocene deposits in comparison to those of an earlier date, but also the nature of most pre-Holocene deposits that are glacial debris (head) and windblown deposits (e.g. sands) rather than marine deposits (e.g. Scourse 1991). Nevertheless there are a small number of sites presented here where stratigraphic and geoarchaeological work has been undertaken, mostly involving the investigation of raised beach deposits.

During the Pleistocene, sea-level is known to have both risen above and fallen below the present day level. These fluctuations are evidenced through the presence of marine and estuarine sediments, including beach deposits, well above modern sea-level and from freshwater sediments, beaches and valley systems now submerged (West 1972; Kidson 1977). In general across the south coast these raised beach deposits are seen at altitudes from present day sea-level to in excess of 30m OD and range from Pliocene to Ipswichian in date. Table 3 summarises the age and altitude of pre-Holocene deposits mentioned in this review.

Table 3: Summary of pre-Holocene deposits in southern England

Date of deposit	Formation	Height in m OD
Pliocene		
	St Erth Beds, Cornwall	20-30
Cromerian		
	Steyne Wood Clay, Isle of Wight	38-40
	Goodwood-Slindon Raised Beach	30+
Unknown date possibly Mid-Pleistocene		
	Aldingbourne Raised Beach	16-24
Wolstonian to post Wolstonian		
	Portland West Raised Beach	10.7
	Brighton–Norton Raised Beach	5-9
Ipswichian		
	Brean Down	9-13
	Bembridge Raised Beach	5-18
	Portland East Raised Beach	6.9
	Burtle Beds, Somerset Levels	3-11
	Stone Pleistocene sequence	0
	Pagham Raised Beach	-1-3

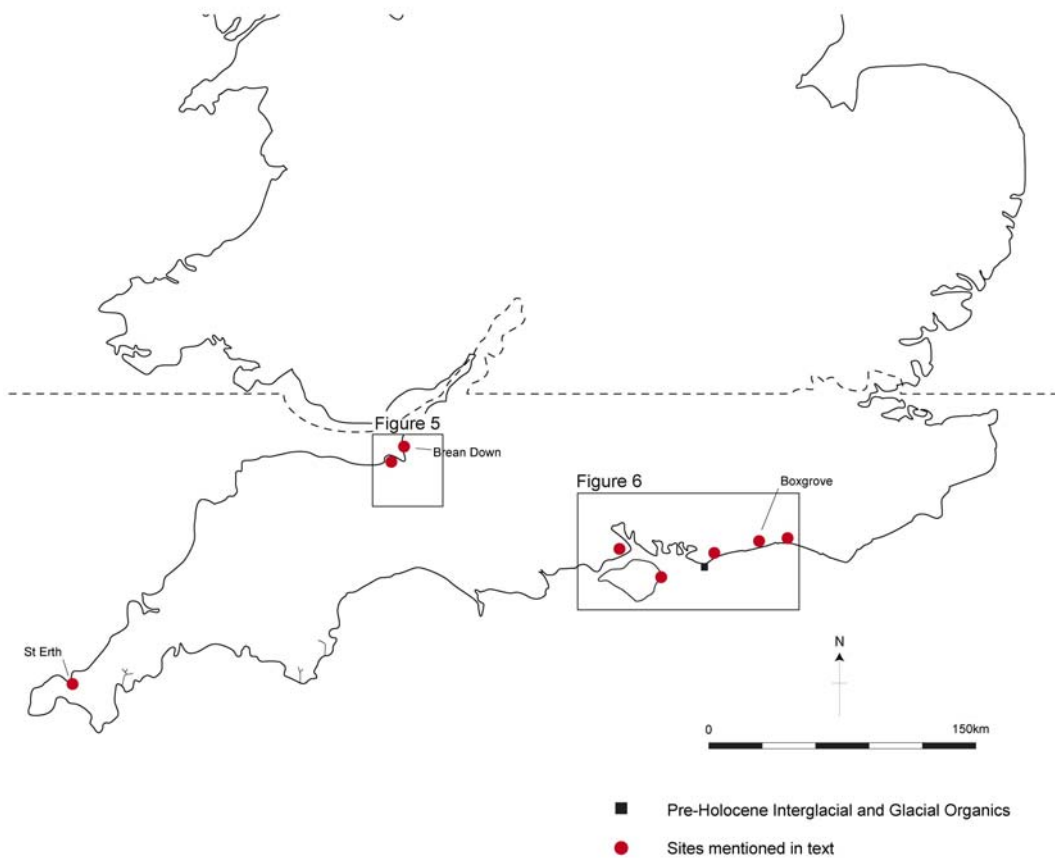


Figure 4: Pre-Holocene sites mentioned in text

The Southwest coast

Along the southwest coast from the Somerset Levels to Cornwall there are a small number of sites with pre-Holocene marine sediments present.

Brean Down

At Brean Down, near Weston-super-Mare, there are exposures of Pleistocene sediments of probable Ipswichian age, which lie at 9-13m OD. The sequence is formed of breccia deposits (a mixture of sedimentary rocks in a consolidated matrix, Unit 13) overlain by a mixture of marine silts and sands (Unit 12) originating from the beach and the down itself, which are overlain by a further Breccia deposit (Unit 11) (see Figure 5). Originally noted by ApSimon *et al* (1961), these sediments were revisited as part of the more recent study conducted by Bell (1990). The sediments were observed to have accumulated against the former base of the limestone cliff face and are overlain by more recent (Holocene) slope deposits. Analysis of the silt and sand layer suggests it is similar in composition to the Slindon Sands sequence at Boxgrove (see below), hence the probable Ipswichian age of the sediment (Macphail in Bell 1990). For more detailed information please refer to ApSimon *et al* (1961) and Bell (1990).

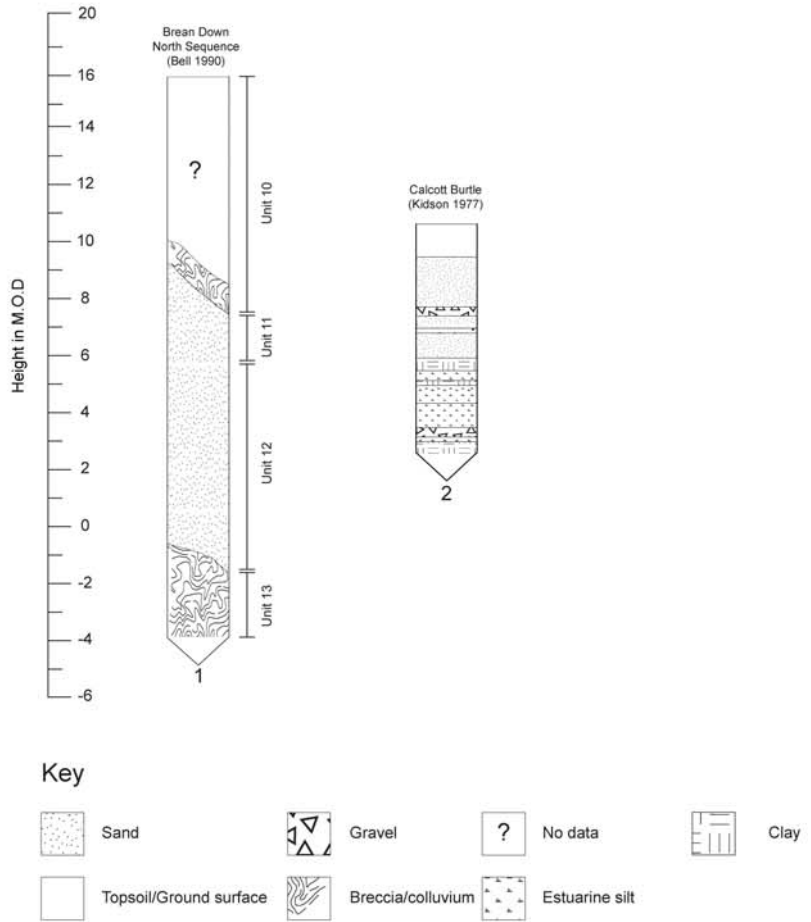
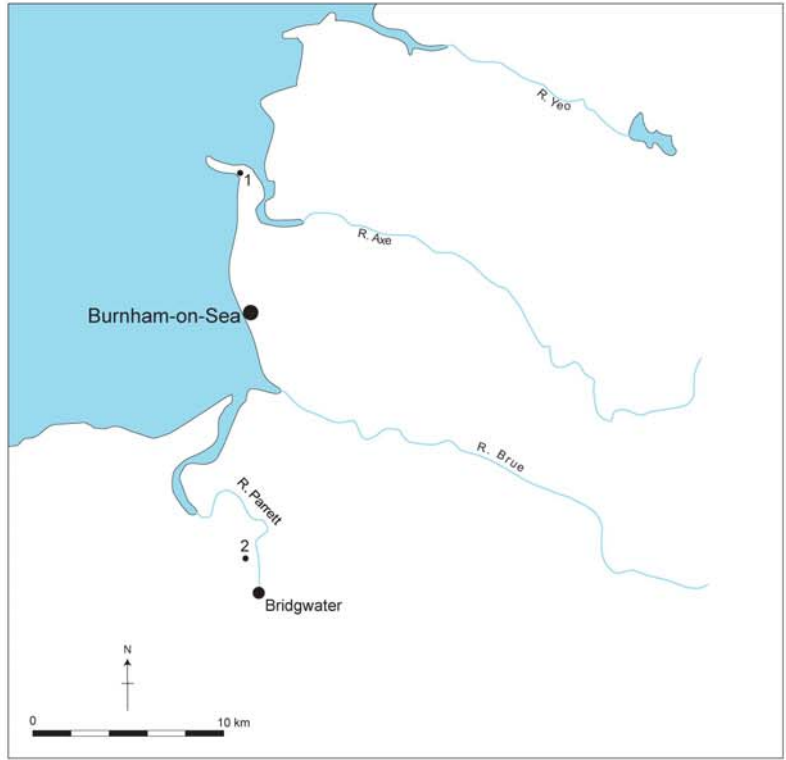


Figure 5: Pre Holocene deposits in the Main Somerset Level (after Druce 1998)

The Somerset Levels

On the Somerset Levels lies the Burtle Beds formation, which takes its name from the village of Catcott Burtle northeast of Bridgewater. This formation of marine silts, sands and gravels lies at between 3 to 11m OD and has been recorded in locations across the Somerset Levels. The deposits themselves are suggested to be of Ipswichian date. The Burtle Beds have been examined by Kidson *et al* (1974) and Kidson (1977) who have shown that there is a pre-Holocene sequence of some 8m in depth. Within this sequence are marine deposits of estuarine silts overlying an intercalated sequence of sands and gravels and overlain in turn by a sequence of clays, sands and gravels (see Figure 5). The marine silts are important as an environmental resource with studies of foraminifera, ostracods and mollusca demonstrating they were laid down within a maritime environment during an interglacial period (the Ipswichian). Kidson *et al* (1974) observe that there has been some reworking of these deposits during a period of falling sea-level at around 3.5m OD, which is likely to represent the beginning of the last glacial period, the Devensian. Kidson (1977) also notes that these deposits are now under threat from tidal erosion, which is damaging the exposed sections. For further reading on these deposits please refer to Kidson (1977) and Kidson *et al* (1974).

Cornwall

The St Erth Beds in South Cornwall, lie at approximately 30m OD and have been suggested to relate to deposition during the Pliocene period, over two million years ago. The rarity of such surviving deposits makes them extremely valuable. The deposits consist of sands (beach and dune) and marine clays overlain by glacial deposits (Kidson 1977; Bates *et al* 2003). Mitchell (1973) undertook analysis of the marine clays looking at foraminifera, ostracods and mollusca in order to characterise the depositional environment. Mitchell's study showed that the deposits were laid down during an interglacial period when conditions were more like that of the current Mediterranean and sea-level would have been at least 45m above present OD. From this data, and the altitude of the deposits themselves, he concluded that the deposits are of Pliocene to early Pleistocene date.

In the west of Cornwall, deposits of marine gravels, which would have been deposited during high-energy wave events, have been sporadically recorded at heights of 20-30m OD. These gravels are thought to be of early Pleistocene age from correlation with altitudes of similar marine gravel deposits in the Channel Islands and that of the St Erth Beds (Scourse 1999). For further reading on the Pliocene deposits of Cornwall please refer to Bates *et al* (2003), Kidson (1977) and Scourse (1999).

The South coast

Pre-Holocene marine sediments are present sporadically along the coast from Cornwall through to Sussex. All of the marine deposits relate to deposition during interglacial periods with high sea-levels, largely of Ipswichian date. Along the south coast these deposits can be seen at heights around the modern high water mark and up to 15m OD. These marine deposits generally lie against fossil cliffs and are overlain by layers of glacial (head) deposits.

The Dorset coast

On the Dorset coast marine sediments of Pleistocene age are present in only one location, at Portland. Here the deposits have been found resting on separate fossil cliff platforms (or benches) at heights of 6.9m (Portland East) and 10.7m OD (Portland West) relating to deposition during the Ipswichian and an interglacial stage within the Wolstonian, respectively (Davies and Keen 1985). The marine deposits have been described by Davies and Keen (1985) and Keen (1985) who found the Portland East deposits to consist of gravels with intermittent pockets of fine gravels and shells in a sandy matrix ranging in thickness of 0.25 to 0.45m. At Portland West the deposits were found to consist of well-sorted sandy gravel of between 1.8 and 2.5m in thickness. Davies and Keen (1985) used altitudinal data and geoarchaeological techniques of mollusca and amino acid analysis in order to confirm the dates of the deposits. For further reading on the deposits of the Dorset coast please refer to Davies and Keen (1985) and Keen (1985).

The Hampshire coast

At Stone on the Hampshire coast two sequences of Pleistocene deposits of Ipswichian age are present at and around present sea-level, an upper and lower sequence (see Figure 6). The sites have been investigated by Brown *et al* (1975) who record a three layer sequence consisting of intercalated clays and peats sandwiched between a lower and an upper gravel layer. The intercalated clay and peat layer can be seen to increase in thickness seaward and reaches a maximum of 2m in thickness, with the thin fen peat layers measuring between 0.02-0.24m in thickness. The thinness of the peats is largely due to compression from the overlying weight of the Upper Gravel layer (Brown *et al* 1975). Pollen analysis of the peats by West and Sparks (1960) has shown that the local environment was one of reed swamp, with surrounding oak woodland, as these fen peats formed during the Ipswichian period. For further reading on the Stone sequences please refer to Brown *et al* (1975) and West and Sparks (1960).

The Isle of Wight

On the Isle of Wight, pre-Holocene marine deposits of Pleistocene age occur near Bembridge. Two sequences have been recorded: an upper sequence known as the Steyne Wood Clay (possibly Cromerian in date) and a lower sequence known as the Bembridge Raised Beach (Ipswichian). These sequences occur at 38-40m OD and 5-18m OD respectively. The Steyne Wood Clay sequence is overlain by up to 3m of a solifluction deposit (see Figure 6). It has been shown by Holyoak and Preece (1983) to have formed during estuarine conditions from a study of diatoms, mollusca, ostracods and foraminifera within the clay. Pollen evidence from the clays showed that this deposition occurred during the Middle Pleistocene. Further dating work by Preece *et al* (1990) has placed the deposition of these sediments to the early to mid Middle Pleistocene indicating formation took place in either the Cromerian or Hoxnian interglacial.

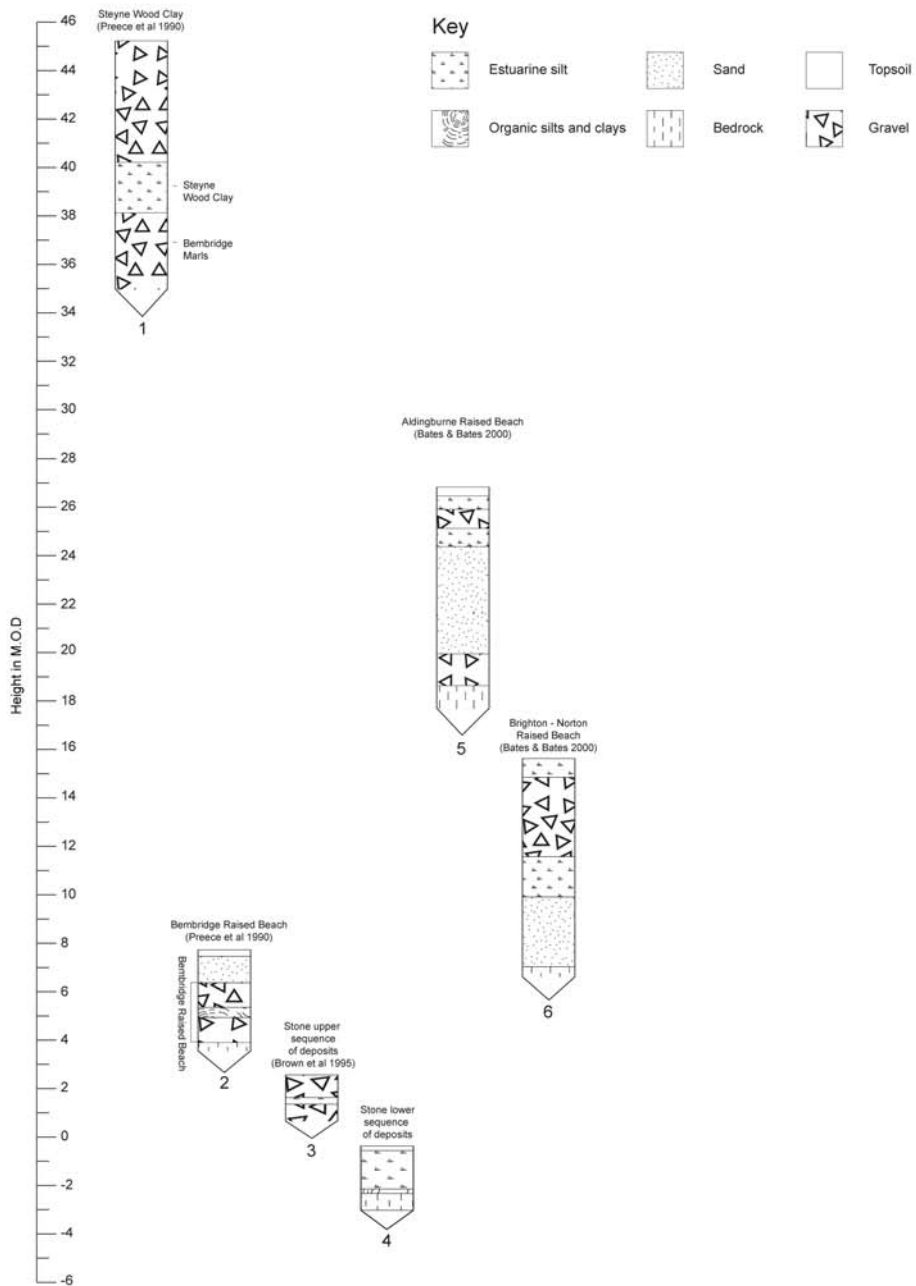
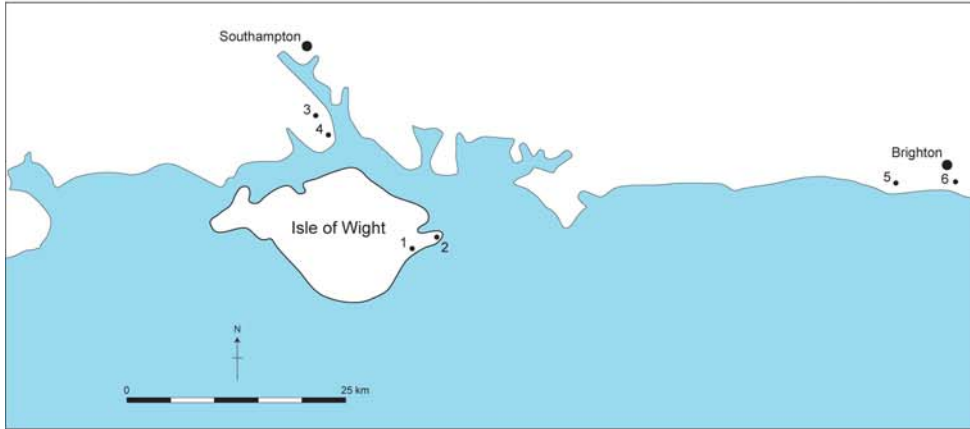


Figure 6: Pre-Holocene deposits of the south coast (after Bates et al 2003)

The Bembridge Raised Beach occurs at a lower elevation, between 5-18m OD and has been shown by Preece *et al* (1990) to consist of a sequence of marine gravels overlain by intertidal sands, then organic silts, representing a former saltmarsh environment. These are overlain by gravels and then a sandy silt layer (see Figure 6). Pollen analysis of the organic silt layer showed that the deposit had formed during an interglacial (Preece *et al* 1990). Comparison with other raised beaches of approximately the same altitude on the southern coastline of England, and those across the English Channel, suggests that this deposit is of Ipswichian age. Preece *et al* (1990) observe that the basal gravels of the Bembridge Raised Beach may represent a fossil spit extending to the east of the Isle of Wight and it may have been similar in appearance to the modern day deposits that underlie the Dungeness Foreland in Kent.

For further reading on the Isle of Wight deposits please refer to Preece *et al* (1990).

The Southeast coast

The Sussex coastline

Along the Sussex coastline raised beaches of largely middle Pleistocene date have been recorded, some lying as far as 17km inland of the present-day coast. These marine deposits are often found under periglacial deposits that may exceed thicknesses of 10m. This has protected the marine deposits but also presents difficulties in accessing them for study. The deposits are important geoarchaeologically as they contain palaeoenvironmental information informing us about past climates and, at Boxgrove, have been found to contain some of the best evidence for the presence of early human populations in the UK.

The marine deposits of the Sussex coastline can be divided into two main features: the Upper Coastal Plain and the Lower Coastal Plain. The Upper Coastal Plain includes a number of sites such as Boxgrove, Steyne Wood, Bembridge (see above) and Portsdown (Holyoak and Preece 1983; Preece *et al* 1990; Roberts and Parfitt 1999; Bates *et al* 2003) and is collectively known as the Goodwood-Slindon Raised Beach. These deposits lie at altitudes in excess of 30m OD and, although still the subject of debate, they are broadly regarded as being of Cromerian age, possibly immediately predating the Anglian glacial period (Bates *et al* 2003).

At Boxgrove in particular, the link between geological and the archaeological evidence is clearer than at any other site containing pre-Holocene deposits. The sequence lies at around 40 m OD and consists of a raised beach deposit lying on chalk bedrock, overlain by marine sands (the Slindon Sands), in turn overlain by solifluction gravel deposits. Here, as well as the sediments, archaeological evidence has been found showing the presence of a hunting camp for early humans. The geoarchaeological significance of the sediments was realised upon the discovery of archaeological material such as knapping debris and lithic finds together with bones showing clear signs of early human butchery activity (Roberts 1986; Roberts and Parfitt 1999). The site is still undergoing geoarchaeological study by a team from University College London and more details of current work can be found at <http://matt.pope.users.btopenworld.com/boxgrove/boxhome.htm>. Recent archaeological

finds have included the skeletal remains (a shin bone and two teeth) of an early human known as “Heidelberg Man” (*Homo heidelbergensis*), present in this part of the British Isles approximately 500,000 years ago.

The Lower Coastal Plain consists of raised beach deposits, which are present in three distinct groups at 16-24m OD, 5-9m OD and around current sea-level at -1-3m OD. The first group of raised beach deposits are typified by the Aldingbourne Raised Beach, which lies between Chichester and Arundel. The sequence here has been found to have been affected by decalcification throughout and lacks any preservation of faunal remains (Bates *et al* 1997). The sequence itself comprises marine sands sandwiched between gravel layers, also of marine origin (see Figure 6) showing that deposition of material largely took place in high-energy beach environments. The date of the raised beach at Aldingbourne is currently unknown, although recent work, such as that at Norton Farm (Bates and Whittaker 1998; Bates and Bates 2000), suggests a middle Pleistocene date, possibly post-dating the Anglian/Elsterian glaciation. The geoarchaeological potential of these sediments is also shown from the findings of archaeological material predominantly consisting of bi-faces (stone artefacts), although typically these are thought to be re-worked assemblages and more study is needed on the taphonomy (Bates *et al* 1997).

The second group of deposits at a slightly lower altitude of between 5-9m OD is known as the Brighton-Norton Raised Beach, with deposits occurring in locations from Brighton back around the coast to Portsmouth. These deposits are thought to date to the end of the Wolstonian stage. The deposits have been studied at Norton Farm and have been found to consist of marine sands overlain by terrestrial silts and sealed beneath solifluction gravels (Bates *et al* 1997, 2000; see Figure 6). Investigation of the marine sands (mollusca and foraminifera analysis) and terrestrial silts (faunal remains, mollusca and pollen analysis) have shown that deposition took place during a period of falling sea-level and deteriorating climate (Bates *et al* 1997, 2000). Archaeological material from deposits relating to this formation is extremely rare with only a single well-made bi-face having been found at Portfield, Chichester (Bates *et al* 1997).

The third group of deposits lie at and around modern sea-level. These exist as relatively small patches of marine gravels, known as the Pagham raised beach and can be seen around Pagham Harbour and Selsey Bill. The age of these marine gravels has been the subject of some debate, with deposition within more than one phase of the middle Pleistocene suggested by some authors. However, recent Optically Stimulated Luminescence (OSL) dating of the underlying sands has refined this, indicating that the gravels were deposited during the last interglacial, the Ipswichian (Bates *et al* 2003). The easternmost stretch of marine gravels from this sequence was recorded at Blackrock, Brighton (Hutchinson and Millar 1998) but cliff erosion has subsequently removed these deposits. As with those of the Brighton-Norton deposits, archaeological evidence for human activities is extremely rare. This is largely due to these deposits mostly not being available for direct observation due to their position below current sea-level, leading to reliance on dredging to locate artefacts. Those artefacts which have been recovered are often re-worked due to their deposition in high-energy environments (Bates *et al* 1997).

For further reading on the Sussex Coastline deposits please refer to the work of Martin Bates and for Boxgrove that of Mark Roberts. Some key texts are Bates *et al* 1997; Bates *et al* 2003; Bates *et al* 2000; Roberts 1986 and Roberts and Parfitt 1999.

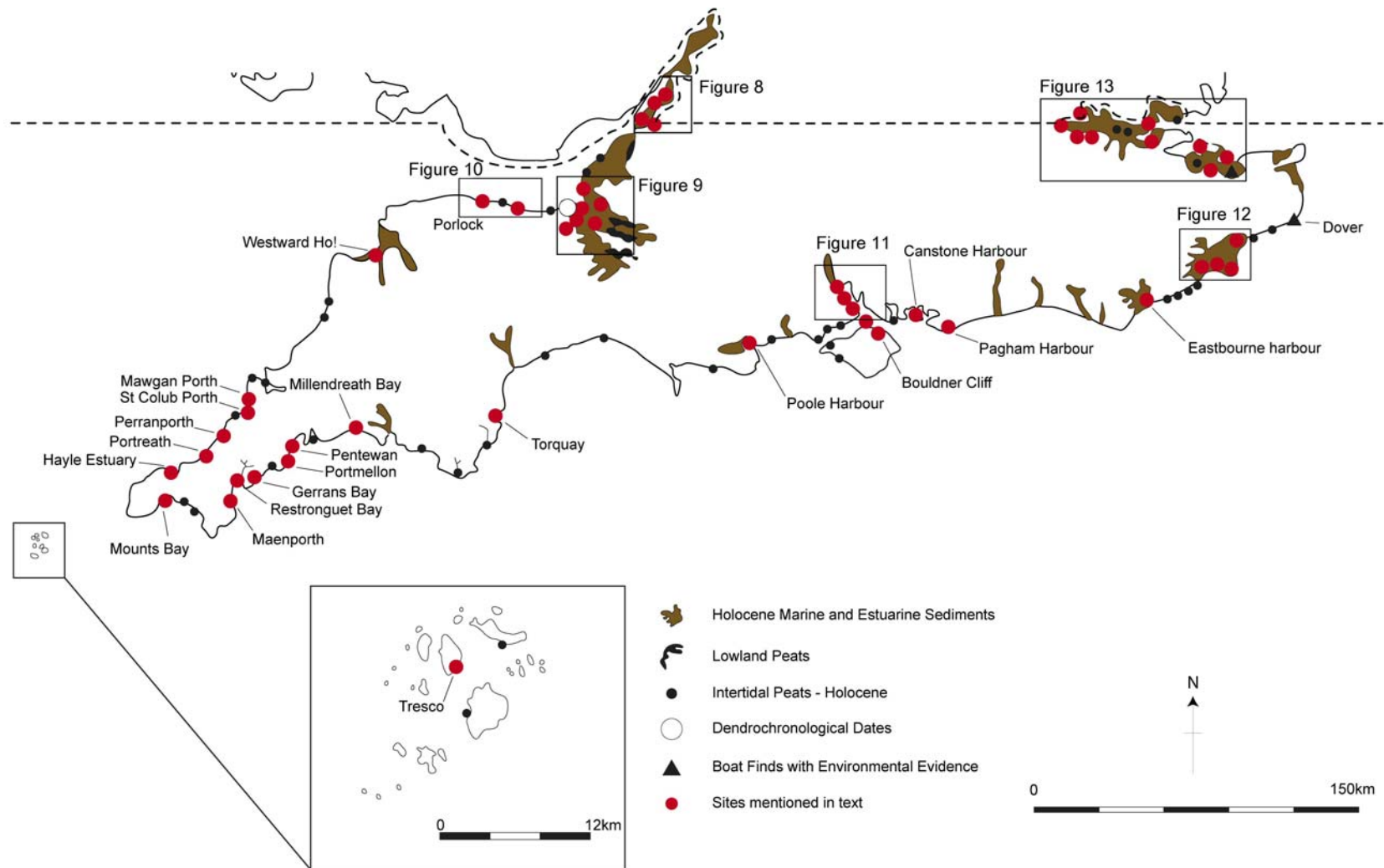


Figure 7: Holocene sites mentioned in text

Remainder of the southeast coast

No pre-Holocene marine sediments are present along the southeast coast or for 275km along the coastline, from Thanet, north to East Yorkshire (Bates *et al* 2003). This is thought to result from major landscape changes associated with the Anglian and post-Anglian glaciations, which caused significant changes to drainage basins and erosion of the soft rock areas within this part of the country.

4. HOLOCENE DEPOSITS

The Holocene marine deposits across southern England have been much more widely studied than those of the pre-Holocene deposits described in Section 3. Here geoarchaeological techniques have been practiced long before the term was even coined with in-depth studies of deposits taking place in the 19th century. The Holocene deposits largely consist of peats and estuarine silts and are therefore an extremely valuable geoarchaeological resource. Due to their waterlogged nature, they can preserve archaeological artefacts (e.g. wooden structures) and palaeoenvironmental material (e.g. pollen and seeds) that would otherwise not survive. The location of the sites mentioned within this section are shown in Figure 7.

The Southwest coast

The Avon Level

The Avon Level on the south shore of the Severn Estuary at Avonmouth (Bristol) contains Holocene deposits with depths in excess of 16m, comprising a full Holocene stratigraphic record (Hawkins 1990; Carter *et al* 2003). The sequences consist of intercalated estuarine silts, fen peats and buried soils (see Figure 8), representing periods of marine transgression when the site was under water (estuarine silts) and periods when the site was a terrestrial surface (peats and buried soils). Thus these sediments have the potential to provide important geoarchaeological information for the area in terms of past sea-level rise and environment together with archaeological finds such as those recovered at Kites Corner (Locock *et al* 1998). The main peat layer has been observed (Carter *et al* 2003) to measure around one metre in thickness in the inner part of the levels and thins out seawards, separating into thinner layers towards the palaeovalley of the Avon.

The deposits have been studied in detail by Carter *et al* (2003) from boreholes taken along the route of the gas pipeline to the Seabank Power Station just north of Avonmouth. The sequence consists of intercalated fen peats and estuarine silt layers overlying bedrock; a buried soil or old ground surface is also recognised within the upper part of the deposit (see Figure 8). The deep sequences encountered along the route were recognised for their geoarchaeological potential, and samples taken particularly from the peats with regard to reconstructing past sea-level (diatoms and foraminifera) and environment (pollen and plant macrofossils). These showed the presence of former alder carr woodlands locally and oak-hazel woodland regionally during the period of upper peat

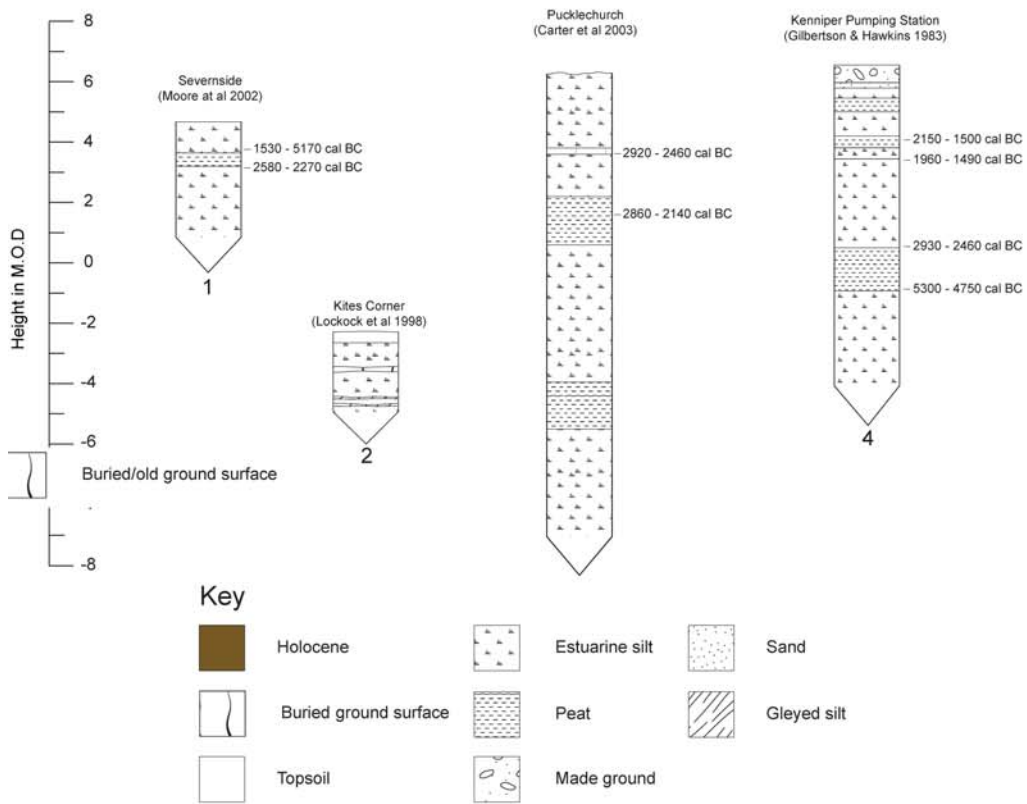


Figure 8 The Avon Level (after Allen 2005)

formation around 2860-2140 cal BC, which was then submerged by marine waters. The lower peat remains undated, though there are dates for the buried soil formation at 2920-2460 cal BC. Carter *et al* (2003) state the reason for this inverted date may be from older carbon present in the deposit.

At Kites Corner, close to Avonmouth and Seabank, a small section of Holocene deposits of around 1.3m in depth were exposed by Locock *et al* (1998) as part of an archaeological investigation of a Bronze Age site (see Figure 8). Scattered finds of burnt stone, pottery, bone and lithic artefacts were discovered at the site, highlighting the archaeological potential of the sediments. The sequence is predominantly of estuarine silts with a fractured band of peat lying within an upper gley sequence; otherwise peats are absent. A buried soil exists, less than 10cm in thickness, which has been radiocarbon dated to around 920-510 cal BC - relatively younger than the buried soil recorded by Carter *et al* above.

Peat layers have been found at Severnside by Moore *et al* (2002) where an archaeological evaluation showed the presence of intercalated silts and peats (see Figure 8). The geoarchaeological potential of the peats was recognised by Moore *et al* (2002) who took samples for pollen and diatom assessment, showing the peats were deposited in a saltmarsh environment with surrounding oak-hazel woodland. The upper peat from this sequence has been dated as forming between 2580 and 1370 cal BC and is approximately 0.45m in thickness. The peat here shows clear signs of having been affected by compression (Moore *et al* 2002). For further reading on the above sites please refer to Carter *et al* (2003), Locock *et al* (1998) and Moore *et al* (2002).

Main Somerset Level

The Main Somerset Level contains a large area of Holocene sediments along the river valleys of the Axe, Brue and Parrett, which can be traced seaward (see Figure 9). As with the Avon Level, the Holocene sequences in the Somerset Levels consist chiefly of estuarine silts and peats (Allen 2000), relating to periods of marine inundation and the formation of terrestrial surfaces. Inland the sequences are dominated by the non-marine peats, which include succession from fen through to raised mire peats, which in some locations would have formed domes in excess of 6m above sea-level (e.g. Housley *et al* 1999). The sequences then grade seawards into estuarine silts of largely salt marsh origin (Allen 2005).

The Holocene sediments within the Main Somerset Level have long been recognised as being extremely important geoarchaeologically and have been widely studied both inland (e.g. Coles and Coles 1986) and along the coast in relation to past sea-level (e.g. Haslett *et al* 1998, 2001), palaeoenvironment and archaeology (e.g. Bell 1990). Allen (2005) observes, from data gathered during these investigations, that a single peat layer exists within the Holocene deposits spanning a distance of approximately 20km in a southeast-northwest direction. This peat layer has a vertical height of a few metres in thickness in places overlying a large depth of estuarine silts (see 5, 6, 7 and 8 on Figure 9).

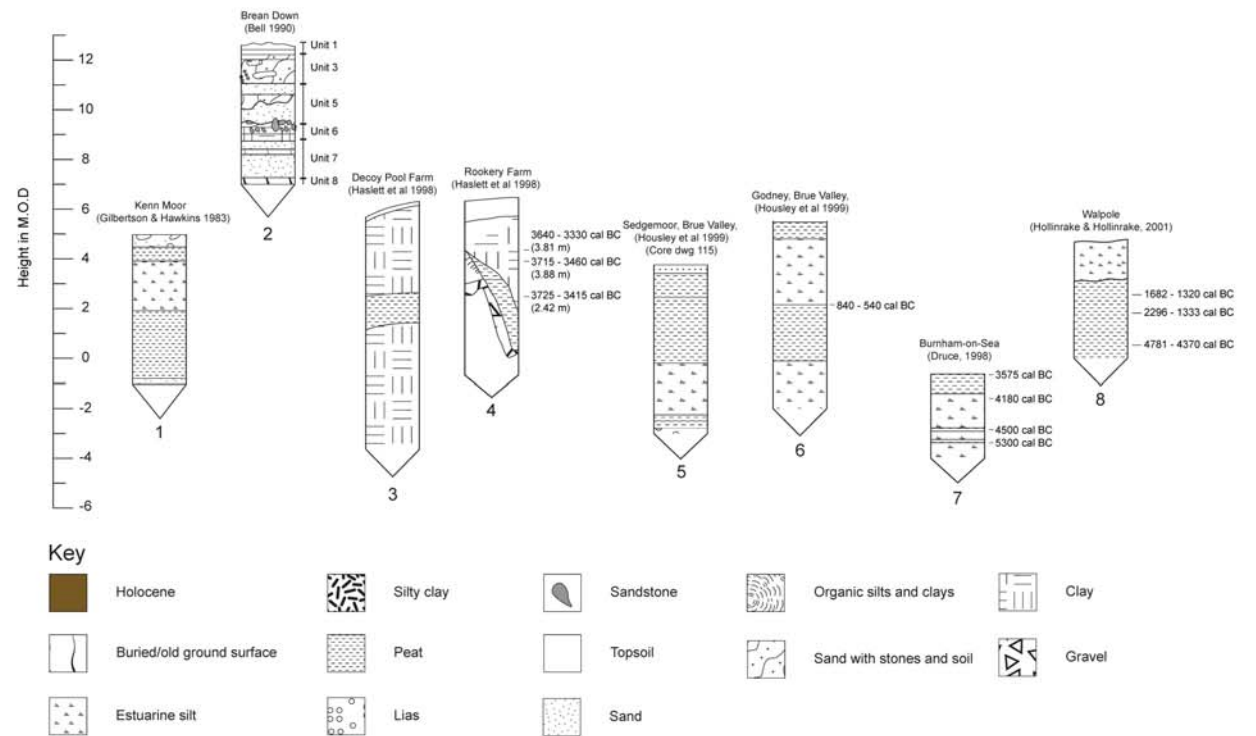
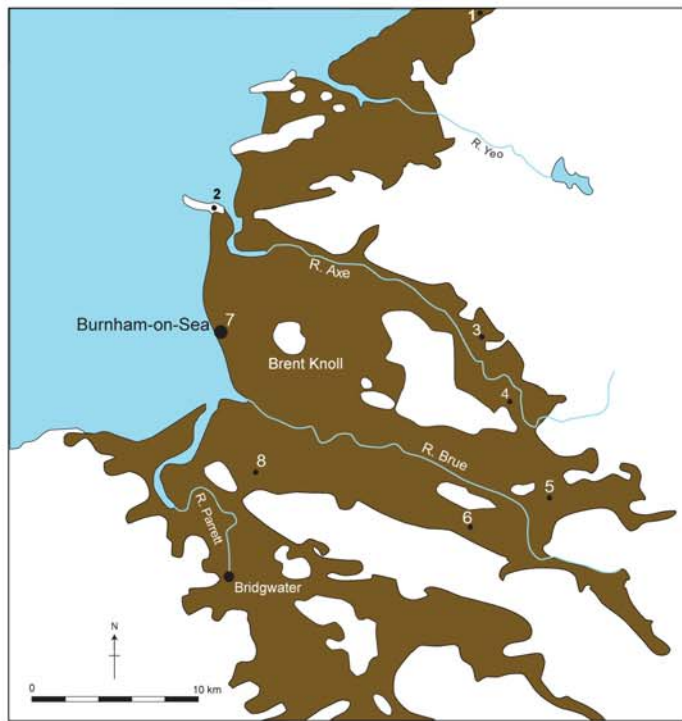


Figure 9: Holocene deposits of the Main Somerset level (after Druce 1998)

The Bristol Channel

Clevedon

At Clevedon, Gilbertson and Hawkins (1983) recorded geoarchaeological investigations of Holocene sequences in two locations, Kenn Moor and Kenniper Pumping Station. The sequence at Kenn Moor consists of silty sand, overlain by a lower wood peat, approximately 1.8m in thickness, which in turn is overlain by silt layer and an upper thinner peat layer (see Figure 10). The top of the upper peat layer is likely to have been affected by human agency with a layer of made ground lying above the peat. The second sequence at Kenniper Pumping Station again shows evidence of an upper and lower peat within silts. Here the lower peat is around 1m in thickness and has been dated forming between 5300-4750 cal BC and 2930-2460 cal BC. It was from this peat that prehistoric wooden timbers were recovered which had been preserved within the deposit. The upper peat can be seen to divide into three layers, which formed between 2150 and 1490 cal BC. These dates show that the lower peat is similar in date to the upper peat observed during the pipeline investigations at Seabank on the Avon Level (above) and begins a trend in peat formation seen further along the coastline. For further reading please refer to Gilbertson and Hawkins (1983).

Brean Down

Geoarchaeological investigations of the Holocene deposits (together with pre-Holocene deposits, see Section 3) were undertaken by Bell (1990) as part of archaeological investigations at Brean Down, carried out between 1983 and 1987. The deposits were of considerable archaeological interest with findings including the remains of Bronze Age structures and a sub-Roman cemetery. The Holocene deposits recorded by Bell (1990) are summarised in Figure 9, which shows the southern end of the deposits. The sequence is largely a result of natural processes, primarily consisting of windblown sands and estuarine silts overlying an old ground surface.

Bell (1990) also observed an exposure of peat on the foreshore 400m to the south of Brean Down, largely covered by tidal mud. The peat was investigated and was found to be a thin fen peat, 0.18m in thickness, overlying estuarine silts which extend to a depth of 2.5m (c.-2.3m OD). A date from the peat suggests it formed at approximately 4720-4710 cal BC. Similar peat exposures have also been found on the foreshore at Stolford. These remaining exposures of peat have high geoarchaeological potential to provide palaeoenvironmental information. However, they are a declining resource, constantly threatened by erosion from tidal action. For further information please see Bell (1990).

The Axe valley

To the southeast of Brean Down, within the valley of the River Axe, Haslett *et al* (1998, 2001) have recorded Holocene deposits of intercalated estuarine silts and peats extending to depths of approximately 10m. The deposits were the subject of geoarchaeological investigations in order to look at past sea-levels at two locations: Decoy Pool Farm and Rookery Farm (see Figure 9). At the former location, a Holocene sequence in excess of 10m was found with a fen peat band 0.92m in thickness between

two layers of estuarine silts. At Rookery Farm this sequence extended to a depth of around 6m. Here the fen peat layer was found to be resting on an old ground surface or head deposit and has a maximum thickness of 2.17m. Radiocarbon dates from borehole samples of the peat show that it formed between 3725-3330 cal BC. However, the sequence proves more complex with the presence of organic clays, sandwiched between the peat and the underlying old ground surface. The base of this deposit has been radiocarbon dated to 6855-6490 cal BC. The peat is overlain by estuarine silts, with the lower silt layer recorded at Decoy Pool Farm being absent from this sequence. Haslett *et al* (2001) observe that the peats in both of these sequences would have been affected to some degree by compaction from the weight of the overlying silt deposits. For further information on the Axe Valley, see Haslett *et al* (1998) and Haslett *et al* (2001).

The Brue valley

The Holocene sequences in the Brue Valley, are similar to those in the Axe Valley consisting of intercalated deposits of silts and peats. The deposits here are seen to be approximately 8m in depth (see Figure 9) including thick peat layers (over 5m) with significant potential for preservation of palaeoenvironmental and archaeological materials.

The deposits in the Brue Valley have been recorded by Housley *et al* (1999) as part of a study of sediments across the upper part of the valley. These deposits are summarised in Figure 9 using two of the forty cores taken across the area, at Sedgemoor and Godney. The sequences show that, in areas such as Sedgemoor, a basal fen peat exists underlying a lower estuarine silt layer. This in turn is overlain by a main peat deposit and capped by a layer of more recent freshwater alluvium. The sequence is slightly different at Godney, where upper estuarine silts overlie the main peat deposit (see Figure 9). The main peat deposit is over 5m in thickness representing a progression from fen to raised mire peat. Similar raised mire peat deposits overlying estuarine silts were also observed in this area by Godwin (1943). The top of the upper peat layer is thought to have been lost due to peat cutting in the area. Where these peat sequences are overlain by estuarine silts they are likely to have been affected by compaction. Radiocarbon dates from the top of this main peat layer at Godney show that peat formation continued until 840-540 cal BC. Also at Godney, Housley *et al* (1999) were able to obtain another date from the top of this peat layer to 1055 cal BC. These dates indicate that the formation of this main peat layer in the Brue Valley continued for a much longer period than in the Axe Valley; however the date for the start of this formation is unknown. For further information on the Brue Valley deposits please refer to Housley *et al* (1999)

Burnham-on-Sea

At Burnham-on-Sea the sequence is, once more, of intercalated estuarine silts and peats, with three fen peat layers (see Figure 9). The upper peat is the greatest in thickness at c. 0.6m but has suffered from tidal erosion at its surface, while the other two peats have been affected by compaction, reducing their thickness to just a few centimetres. Radiocarbon dates have been obtained from these peat layers; the lower two peats forming at around 5300 and 4500 cal BC, while the upper peat formed between 4180 cal BC and 3575 cal BC (Druce 1998). The dates of this peat tie in well with the main peat layer of the Axe Valley (Haslett *et al* 1998) and that at Brean Down (Bell 1990). The geoarchaeological potential of these deposits was recognised by Druce (1998) who

undertook a palaeoenvironmental study. Pollen analysis through the peat layers showed the presence of oak-hazel woodland with saltmarsh communities present locally. For further information on the work undertaken at Burnham-on-Sea please refer to Druce (1998).

Walpole

Holocene sediments present at Walpole, near the Polden Hills are similar in composition to those found elsewhere in the Main Somerset Level, consisting of intercalated silt and peat. The sequence at Walpole was investigated by Hollinrake and Hollinrake (2001, 2006) as part of archaeological evaluation works. A summary of the sequence discovered is given in Figure 9 and shows estuarine silts overlying a peat deposit of approximately 3m in thickness. Again it is likely the peat will have been affected by compaction from the weight of the overlying silts. Formation of this peat deposit has been radiocarbon dated to between approximately 4780 to 1320 cal BC. This again places the formation of the peat deposit within a time period similar both to those mentioned above and to peats further inland within the Somerset Levels (Coles and Dobson 1989).

For further information on the sediments at Walpole please refer to Hollinrake and Hollinrake (2001) and Hollinrake and Hollinrake (2006).

The outer Bristol Channel

Within the area of the outer Bristol Channel, there are small isolated areas of Holocene deposits present at locations around Minehead and Porlock Bay (see Figure 10). These deposits consist largely of exposures of Holocene peats underlain by estuarine silt deposits. The outcrops represent a diminishing geoarchaeological resource, which is being lost through erosion from tidal action. These remaining deposits have the potential to inform us on the past environment at these locations and may also hold archaeological evidence for the presence of human communities. The peat outcrops are largely of Mesolithic to Neolithic age a period of dynamic human economic and environmental change and thus these deposits represent an important resource to increase our understanding of these changes.

At Minehead there is an early record by Dawkins (1872) of submerged forest within in an intertidal peat. More recently the area has been re-visited by Jones *et al* (2004) who recorded a sequence of thin peat layers within a sequence of intercalated peats and estuarine silts (see Figure 10 for summary). This sequence is exposed on the foreshore, on scattered ledges of differing heights, which are currently subject to erosion. The layers have provided early dates, with the lowest fen peat dating to between 5670 and 5830 cal BC, while the base of the upper wood peat is 4780-4460 cal BC (Jones *et al*/2004).

West of Minehead lies Porlock Bay, where peats have been found of a similar date to those at Minehead. Sea-level and palaeoenvironmental studies by Canti *et al* (1995) and Jennings *et al* (1998) within Porlock Bay have shown there to be Holocene deposits present which are of around 10m in depth. The sequence is made up of a lower part consisting of silt, clays and up to three thin peats, while the upper part of the sequence

comprises clays and silts with occasional shelly sands and gravel deposits, with no peat layers evident (see Figure 10). The uppermost peat is the most widespread and thickest (up to 0.45m) and has been dated between 4200 and 3540 cal BC. The lower peats are shown to have formed between 6650 and 4930 cal BC (Jennings *et al* 1998). The presence of submerged forest is also noted by Canti *et al* (1995) and Jennings *et al* (1998), with two tree stumps producing dates that place the former woodland as having existed at 4750-4550 and 4720-4550 cal BC. This places the development of the woodland towards the end of the period of lower peat development at Porlock. It is likely this woodland is part of the same deposit seen by Dawkins in the late 19th century.

Allen (2005) suggests the absence of young peats and the small depth and discontinuous character of the uppermost peat layer at Porlock may reflect a major hiatus (gap) in peat development due to coastal change. In four of the boreholes the uppermost peat was found to be overlain with either gravelly or shelly deposits and in another core, where peat was absent, a gravelly silt occurs at around the same altitude as the peat layers. Allen (2001) observes that such a hiatus in the sequence is not uncommon within Holocene sequences. For further information on the sediments of the Outer Bristol Channel please refer to Canti *et al* (1995), Jennings *et al* (1998) and Jones *et al* (2004).

Barnstaple Bay

Similar to Minehead and Porlock, exposed areas of Holocene deposits are also present in Barnstaple Bay. Again, these sediments are largely peats overlying estuarine silts. The peats are Mesolithic to Neolithic together with exposures of Roman Age. The problem of erosion is once more evident at Barnstaple Bay and thus the potential for geoarchaeological investigation of these deposits is finite.

The site most studied in Barnstaple Bay is Westward Ho!, which first came to prominence with the discovery of submerged forests and associated wood peat layers in the early 19th century (Risdon 1811; Ellis 1863; Pengally 1868; Rogers 1908). It was these early accounts of the deposits which led Jenkyns (1969) to recognise the geoarchaeological potential of the site and conduct a palaeoenvironmental study. A radiocarbon date was obtained from the top of the upper peat layer (5740-5300 cal BC) suggesting that it predates that of the submerged forest at Porlock.

The Holocene sequence at Westward Ho! was revisited by Balaam *et al* (1987) for archaeological and palaeoenvironmental investigations. Balaam *et al* recorded three outcrops of Holocene peats on the foreshore, which have more recently been re-recorded by Riley (2002), who found significant loss to the deposits from coastal erosion. The third peat (Area 3), part of the "outer peat" sequence, is summarised in Figure 10. The peat deposits are of various dates and thicknesses but all can be seen to overlie estuarine silts. The outer peat, however, also contains a prehistoric occupation layer (containing midden material of shells and charcoal), which is sandwiched between the two. Radiocarbon dates from the outer peat in Area 2 and 3 indicate that it was formed between 5810 to 3630 cal BC, suggesting it formed during the same period as the lower peat at Minehead and Porlock together with the main peat of the Somerset Level (see Figure 9). The occupation horizon has been dated to between 6200-5550 cal BC giving it a Mesolithic age (Balaam *et al* 1987). The inner peat of Area 1 is suggested to be somewhat younger

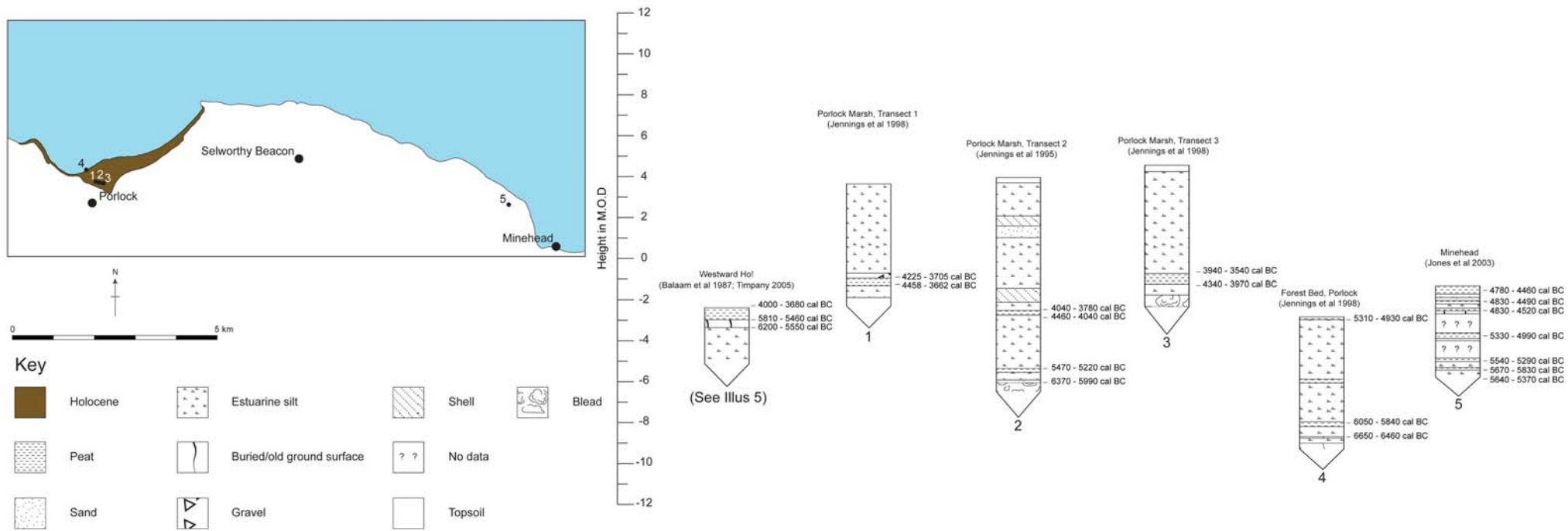


Figure 10: Holocene deposits on the north coast of Somerset (after Allen 2005)

in date with a wooden stake in the peat suggesting peat formation occurred around cal AD 250-620 (Balaam *et al* 1987).

For further information on the deposits within Barnstaple Bay please refer to Balaam *et al* (1987) and Jenkyns (1969).

Scilly Isles

On the Scilly Isles, three inter-tidal peat deposits have been recorded off the southern coasts of St Martin's and Tresco during archaeological investigations (Fowler and Thomas 1979; Ratcliffe and Sharpe 1991). There are two areas of peat at Par Beach, St Martin's. These deposits are very thin (between 1 to 5cm in depth), lying between 0.06m and 0.34m OD, and are stratified between sand deposits of possible former dune systems (Ratcliffe and Sharpe 1991). At Tresco an exposure of peat was found between 0.89m to 1.42m OD and is approximately 0.2 m in depth. The peat was found to overlie sand in both test pits at Tresco, similar to that at St Martin's. Ratcliffe and Sharpe (1991) suggest that the peat formed over an earlier dune system after inundation by rising sea-levels had turned the area into a brackish bog. For further reading on the deposits on the Scilly Isles please refer to Ratcliffe and Sharpe (1991).

Cornwall

Along the coast of Cornwall, Caseldine (1980) has described the geoarchaeological potential of the area for palaeoenvironmental study, mentioning a number of sites where submerged peats are present and thus could provide valuable information to add to our knowledge of the past landscape of this area. These submerged peats are present at Mawgan Porth, St Columb Porth, Perranporth, Portreath, Hayle Estuary, Mounts Bay, Maenporth, Restronguet Bay, Gerran's Bay, Portmellion, Pentewan and Millendreath Bay (see Figure 10). However, Caseldine recognises that many of these peats are in locations difficult to reach, which may explain the lack of further studies in this area. For further information on these deposits please refer to Caseldine (1980).

The South Coast

Torquay

Deposits at Torquay appear to have been little studied since the late 19th century. Early accounts of an intertidal peat at Torquay on the Devon coast are given by Lyell (1875). He observed a submerged forest, which contained trunks, stumps and roots of trees belonging to a former woodland environment. At this time (the late 19th century) the peat and forest was noted to extend for about three-quarters of a mile from the shore. It is unknown how much of this peat currently survives today. Lyell's early study attempted to trace the peat around the coast line using the presence of submerged forests to link the peats. Lyell succeeded in relating the peat to those mentioned above at Porlock Bay, Somerset and as far round as Denbigh in North Wales. However, without dates it is uncertain as to how the chronostratigraphy of these peat deposits ties together. Thus the sequence at Torquay should be viewed as an important geoarchaeological resource that

could be a focus of future studies. For further information on the Torquay deposits please refer to Lyell (1875).

Poole Harbour

Holocene deposits were recorded as part of geoarchaeological studies including palaeoenvironmental and sea-level investigations by Long *et al* (1999). A relatively short sequence of around 2m in depth was recorded, which showed a sequence of a basal peat some 0.2m in thickness lying on bedrock. A date from the top of this peat layer puts the cessation of peat formation at 1530-1250 cal BC. Overlying the basal peat is an intercalated sequence of estuarine silts and organic silt layers (see Figure 11), caused by the periodic formation of saltmarsh within the harbour. Similar sequences to that described by Long *et al* (1999) have more recently been described by Edwards (2001) when again investigating sea-level change within the Poole Harbour area. A summary of Edwards's results from Core ARNI-95-140 is given in Figure 11; no further radiocarbon dates were taken. For further information on the Poole Harbour deposits please refer to Long *et al* (1999) and Edwards (2001).

Southampton Water (The Solent)

Southampton Water occupies the now-submerged palaeovalley of the River Solent and incorporates the estuaries of the rivers Itchen, Test and Hamble (see Figure 11). Extremely deep Holocene deposits of intercalated silts, sands and occasional peats have been recorded along the length of Southampton Water. The large depths of deposits make them very valuable for geoarchaeological study as they have the potential to contain high-resolution palaeoenvironmental records for the whole of the Holocene. Of particular value are the prehistoric peats, which have been recorded at locations such as Fawley and Dibden Bay.

Holocene deposits have long been known to exist in this area and were first studied in the late 19th century by Shore and Elwes (1889), who recorded a peat layer up to six feet in depth, containing the remnants of submerged forest, which was underlain by estuarine silts. The submerged forest at Southampton was later referenced by Clement Reid (1913). The deepest peats currently recorded in the area lie offshore of Dibden Bay; these are over 2m in thickness and may relate to the peats described by Shore and Elwes.

Recent studies have shown that the Holocene deposits are extremely deep with recorded depths in excess of 25m in places (see Figure 12) and largely consist of intercalated sequences of silts, sands and gravels with some peats (Hodson and West 1972; Long and Tooley 1995; Long *et al* 2000). Stratigraphic and palaeoenvironmental investigations by Long *et al* (2000) have shown the presence of a sequence of intertidal peats along the length of Southampton Water. The peats in these sequences can be seen to be variable in date and in thickness (see Figure 11). The peats include a mixture of basal peats overlying gravels, shelly deposits and silts, the earliest of which have been dated to forming around 5650-5000 cal BC at Fawley. Sporadic development of other basal peats continues until around 3650 cal BC at Dibden Bay and Stansore Point (Long and Tooley 1995, Long *et al* 2000). These peats have been recorded just under 1m in thickness at locations such as Hythe Marshes and have been noted to contain wood

fragments, marking them out as wood peats, which may relate to the peats of the early submerged forest studies.

The basal peats are overlain by estuarine silts with younger peats present towards the top of the sequences. At some locations these younger peats lie at around 0m OD and have thus been affected by current tidal erosion. A range of dates can be seen for the younger fen peats, with periods of formation at around 2500-1750 cal BC and continuing at Hythe Marshes up to cal AD 660-890 (Hodson and West 1972; Long *et al*/2000). It is likely that the broad variability in peat development at Southampton Water is due to changing local factors. Allen (2005) suggests the comparative lack of peats within some of the recorded sequences could be a response to low levels of fine sediment availability related to the modest tidal range of the area and its small catchment. Compaction may also have played a role, which is again linked to the deep basement of this area. For further reading on the deposits at Southampton Water, good references to start with are Long and Tooley (1995) and Long *et al* (2000).

Langstone Harbour

The geoarchaeological potential of sediments at Langstone Harbour, was recognised by Clapham and Allen (2000) who looked at the Holocene sediments in relation to archaeological and palaeoenvironmental investigations. The sequence was shown to be intercalated peats and silts. The wood peat on the foreshore was found to contain submerged forest of trunks and stumps of oak, yew, willow/poplar and alder. One oak stump gave a radiocarbon date of 2310-1950 cal. BC and an oak branch gave a further radiocarbon date of 3350-2910 cal. BC (Clapham and Allen 2000). The dates from the submerged forest suggest the formation of this wood peat is of similar date to the end period of formation to the basal peats at Southampton Water (also associated with submerged forest) and that of the main peat deposit seen on the southwest coast. For further information on the deposits at Langstone Harbour please refer to Clapham and Allen (2000).

Isle of Wight

Holocene sequences have been recorded at an offshore location near to Bouldner Cliff, in the Solent. The offshore nature of these deposits makes studying them extremely difficult to access as they are constantly underwater so no tidal window exists. Here, as at Langstone Harbour and Southampton Water, intercalated peat and silt deposits are present. The sediments are currently the subject of geoarchaeological investigation by Hampshire and Wight Trust for Maritime Archaeology. As with other sites around this area, submerged forest is once more present within wood peat deposits present at - 11.5m OD. Radiocarbon dates from a deposit immediately below the peat were of approximately 7590 to 7400 cal BC, suggesting an early date for peat formation. This early date would suggest the wood peat at Bouldner is amongst the earliest peat deposits across southern England. No current published material is available for this site yet, but further information can be found at <http://www.hwtma.org.uk/>.

The South East coast

Eastbourne

On the Pevensey Level in Eastbourne, Jennings and Smythe (1987) recorded Holocene deposits of intercalated estuarine silts and peats. Here a peat deposit termed the "Willingdon Peat" (approximately 1m in thickness) has been dated between 2140-1690 cal BC. The dates for its formation are similar to that of the upper peats seen along Southampton Water. The Willingdon Peat has elsewhere been recorded as having divided into two layers in an intercalated sequence with estuarine silts. In these locations silts are recorded as being extremely thick, in places up to 10m in depth (Jennings and Smythe 1987). Allen (2005) notes that the catchment which supplies sediment to the Pevensey Level is quite small, suggesting the upward growth of mudflats and saltmarshes in this area could have been supply-limited. For further information on Eastbourne and the Pevensey Level please refer to Jennings and Smythe (1987).

Walland and Romney Marsh area

The Walland Marsh and Romney Marsh, together with the floodplain of the rivers Brede, Tillingham and Rother, form the largest area of Holocene estuarine and coastal deposits on the shores of the English Channel, measuring some 300km² (Allen 2005). A number of geoarchaeological studies, including stratigraphic and palaeoenvironmental investigations have been undertaken in this area, which have provided information on the Holocene deposit sequence and formation (e.g. Tooley and Switsur 1988; Long and Innes 1993, 1995; Long *et al* 1998, 2006; Spencer *et al* 1998; Waller *et al* 1999, 2006; Long 2000; Waller 2002). Results from of these studies are shown in Figure 12.

The Holocene sequences, have been shown to consist of basal sands and gravels, overlain in the uppermost 5-10m by intercalated sequences of estuarine silts and peats including a thick layer of peat, termed the 'main peat' (usually between 1-3m in thickness). In some locations these sequences have been recorded up to 20-30m in depth. In places these sequences are cut by palaeochannels infilled with sand. Long *et al* (2006) have recorded one such sequence at Rye on Walland Marsh, where sediments reach depths of 25m and the main peat layer is around 2m in thickness (see Figure 12). The main peat layer is recorded as containing both fen and wood peats, with the exception of the southwest-central part of the area where it is largely a raised mire peat (Waller *et al* 1999; Waller 2002). Today this peat lies below 1-4m of estuarine silts at 3 to -2.5m OD following a period of marine inundation and deposition of the silts. Long *et al* (2006) note that these silts have significantly altered the thickness of the main peat deposit through compaction causing variation in height of up 3m for this deposit.

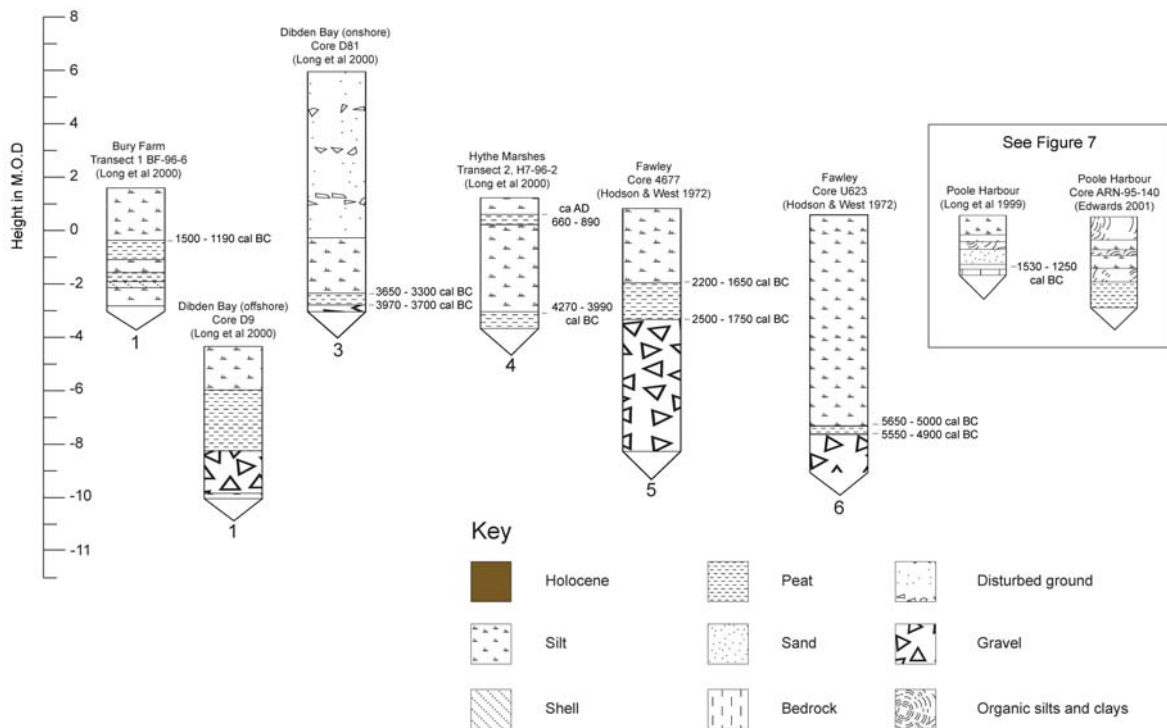
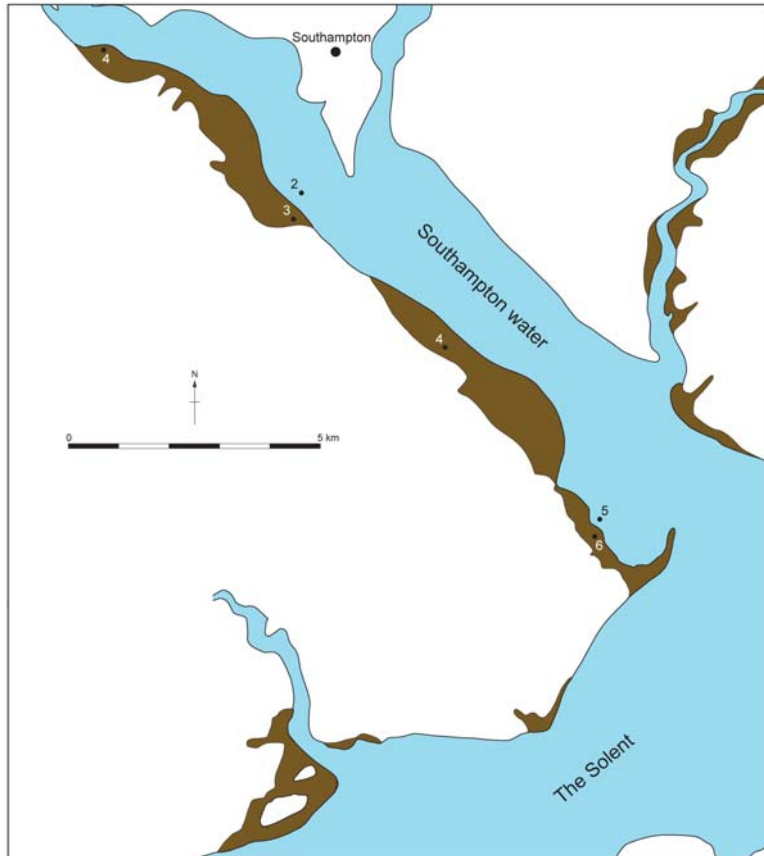


Figure 11: Holocene deposits of the English south coast (after Allen 2005)

The main peat is known to be thickest in the river valley sequences where it is present at around 6m thick; it then thins out into the marshes and by the time it reaches the present shoreline is less than 1m. At Walland Marsh it has been recorded as around 2m in depth but in Romney Marsh this is reduced to a few centimetres. Here the peat layer is seen to have been reduced through erosion by sands and silts (Allen 2005). Long *et al* (2006) also observe that this peat has been affected by peat cutting for fuel in locations such as Rye.

The development of the peat has been dated from a series of radiocarbon dates (some of these are shown in Figure 12). Geoarchaeological studies have attempted to map the distribution of the peat (see Long *et al* 1998 and Long 2000) and suggest that the main peat formed earliest along the northwest margin of the Holocene deposit and most recently at Dungeness. It began to accumulate at around 4900 cal BC, a time when MSL rise had slowed and the development of peat was protected from the tide by a coastal (gravel) barrier present at Dungeness. Long *et al* (1998) suggest this peat development reached its maximum extent at around 1500 cal BC. After this time the peat began to be submerged and estuarine silts were deposited, first at Walland Marsh, which was completely inundated by around cal AD 350 (Spencer *et al* 1998; Long *et al* 2006). However, a true end date for peat formation may not be known due to a combination of erosion and peat cutting disturbing the top of the peat deposit.

Further minor areas of Holocene sediment, similar in nature to those in Romney Marsh, occur to the west (Jennings and Smythe 1987, see above). The closest of these is at the blocked estuary of Combe Haven, Hastings. Here sequences have been recorded comprising approximately 20m of intercalated silts and peats; two radiocarbon-dated peat layers are present. The lower and thinner peat dates to 4900-4630 cal BC, with the upper and thicker peat (c.4.7m) dated to 3940-230 cal BC. This later peat broadly relates to the main peat at Romney Marsh (Jennings and Smythe 1987). Allen (2005) states that compaction has affected the accumulation and preservation of the deposits at Combe Haven. For further information on the Walland and Romney Marsh areas good references to start with are Long *et al* (1998); Long (2000) and Long and Innes (1993).

The Thames Estuary

The Thames Estuary has long been a focus of geoarchaeological studies in respect to the archaeology of the area and the development of the River Thames. The Holocene deposits of the Thames generally comprise estuarine silts and up to five separate intercalated peat layers known as the Tilbury peats. The deposits can be seen to increase in depth from the inner estuary to the outer estuary where, in locations such as the Isle of Grain, they can be seen to be extremely deep (in excess of 30m). These large depths of sediment make them extremely valuable geoarchaeologically as they have the potential to inform on palaeoenvironmental change through the whole of the Holocene.

Early studies of the Thames Estuary (like many early studies noted in other areas) make observations of submerged forests within peat deposits. One such study of note is Lang's description (in Cunnington 1927) of the submerged forest at the mouth of the River Char. This former woodland had been noted prior to Lang in 1831 by De la Beche but not described in any detail. Lang recorded the submerged forest to be in patches some six foot in length by four foot in width and 1-2 feet high, resting on clay. Overlying the peat was a grey clay containing antlers and bones of red deer and hazel nuts containing

gnaw marks of field mice. The branches and other wood contained in the peat were thought to be chiefly of birch (Cunnington 1927).

More modern studies have recorded the Holocene deposits in more detail and to greater depths, thanks largely to commercial borehole information from construction work. The analysis and interpretation of this data in the Thames Estuary was largely undertaken by Devoy (1979) who began to relate the stratigraphic sequences along the length of the Thames, from central London to the Isle of Grain. Devoy found that Holocene sediments are present in substantial but narrow outcrops along the Thames valley, which are progressively thicker as you move west to east along the Thames; in some areas sequences in excess of 30m in depth have been recorded (see Figure 13). These sequences are essentially similar in nature to those already described along the south coast, consisting of intercalated gravels, sands and silts together with peat and organic mud deposits. The sequences can be seen to largely rest on gravel surfaces, which Devoy notes as Devensian in age (the last glacial period). Overlying the gravel in places is a basal peat (Tilbury I), which is the first of five separate peat layers, which Devoy recorded along the length of the Thames. The upper four peats (Tilbury II-V) occur in an intercalated sequence with silts, with Tilbury II sometimes seen as the basal peat within shallower sequences inland (see Figure 13).

The five Tilbury peats mark out periods of stable peat development, which were then inundated by rising sea-level, depositing silts. The thickest and most extensive peat is Tilbury III within the lower Thames, which is in excess of 3m in some localities (see Figure 13). The basal peats are thinner, being just a few centimetres in thickness and are likely to have been affected by compaction from the overlying deposits. The peats (a mixture of wood and fen peats) have been radiocarbon dated to provide information on when they were formed. The basal peats (Tilbury I or II) were formed between approximately 7500 and 5900 cal BC, indicating a similar period of formation as the offshore peats recorded at Bouldner Cliff, off the Isle of Wight. The main period of peat formation and accumulation of the thickest deposits (Tilbury III) took place between approximately 4300 to 2550 cal BC. This peat includes wood peat, which has been noted to contain large wood fragments and may relate to the submerged forest deposits noted on the River Char in the early 20th century. The upper peats (Tilbury IV and V) represent accumulation over much shorter periods of time and were formed around 1700 cal BC and cal AD 300 (Devoy 1979).

Further up the estuary are the thinner sequence of central London (Sidell *et al* 2000). Here, gravels are overlain by a thick, continuous peat, which broadly dates to the same time of formation as the Tilbury III and IV peats in the outer estuary and the main peat of the Somerset Level (Allen 2005). Although much shallower than those sequences of the outer estuary, these sediments are rich in archaeological materials (e.g. Meddens and Sidell 1995) and have provided important palaeoecological information on the past environment of London (e.g. Sidell *et al* 2000). On the south side of the Thames Estuary, in the Kent Marshes and the Medway, peat and organic mud sequences have also been recorded with dates similar to those within the Tilbury II-V sequence (Barham *et al* 1995; Firth 2000, see Figure 13). For further information on the Thames Estuary area, good starting points are Devoy (1979) and Sidell *et al* (2000).

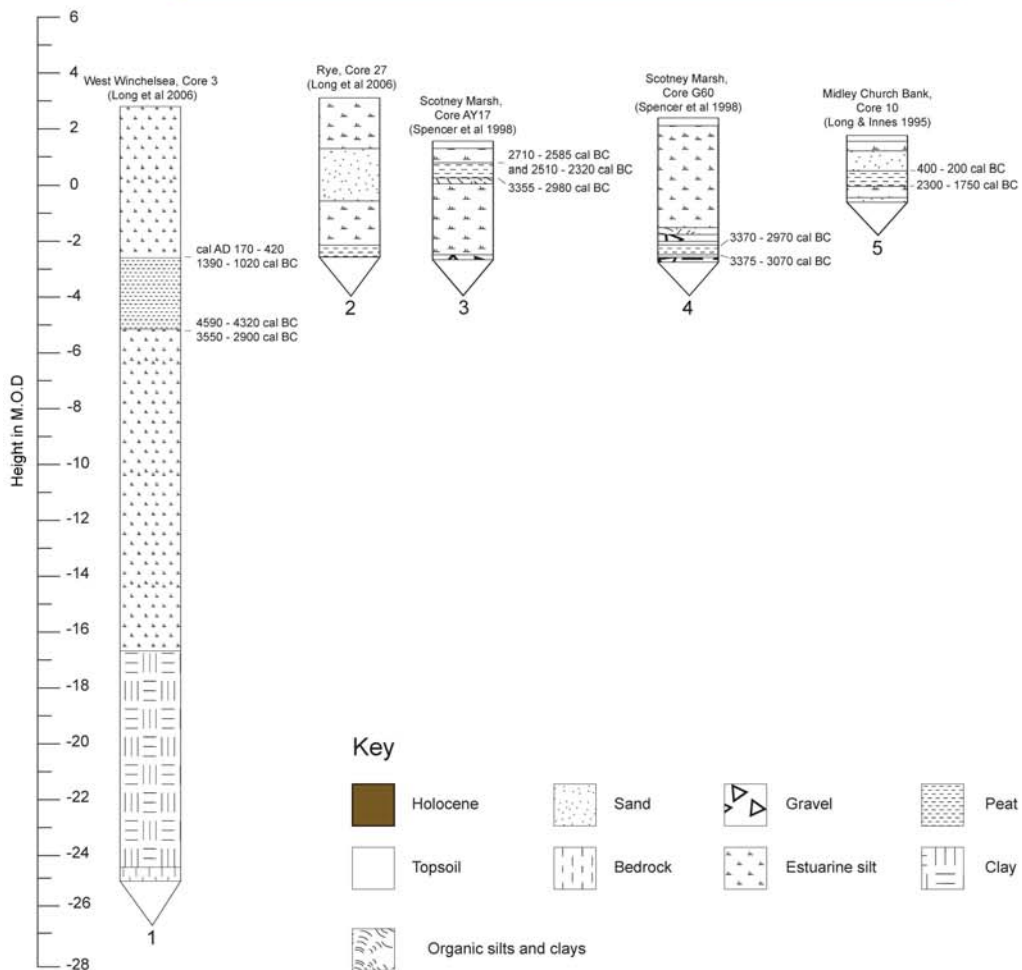
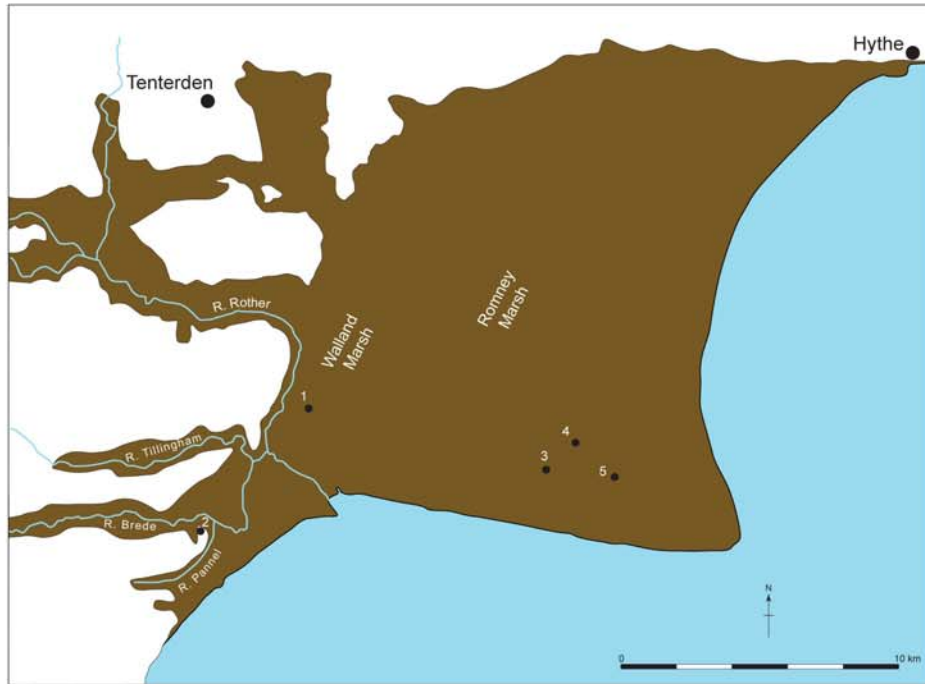


Figure 12: Holocene deposits of the Romney Marsh area (after Allen 2005)

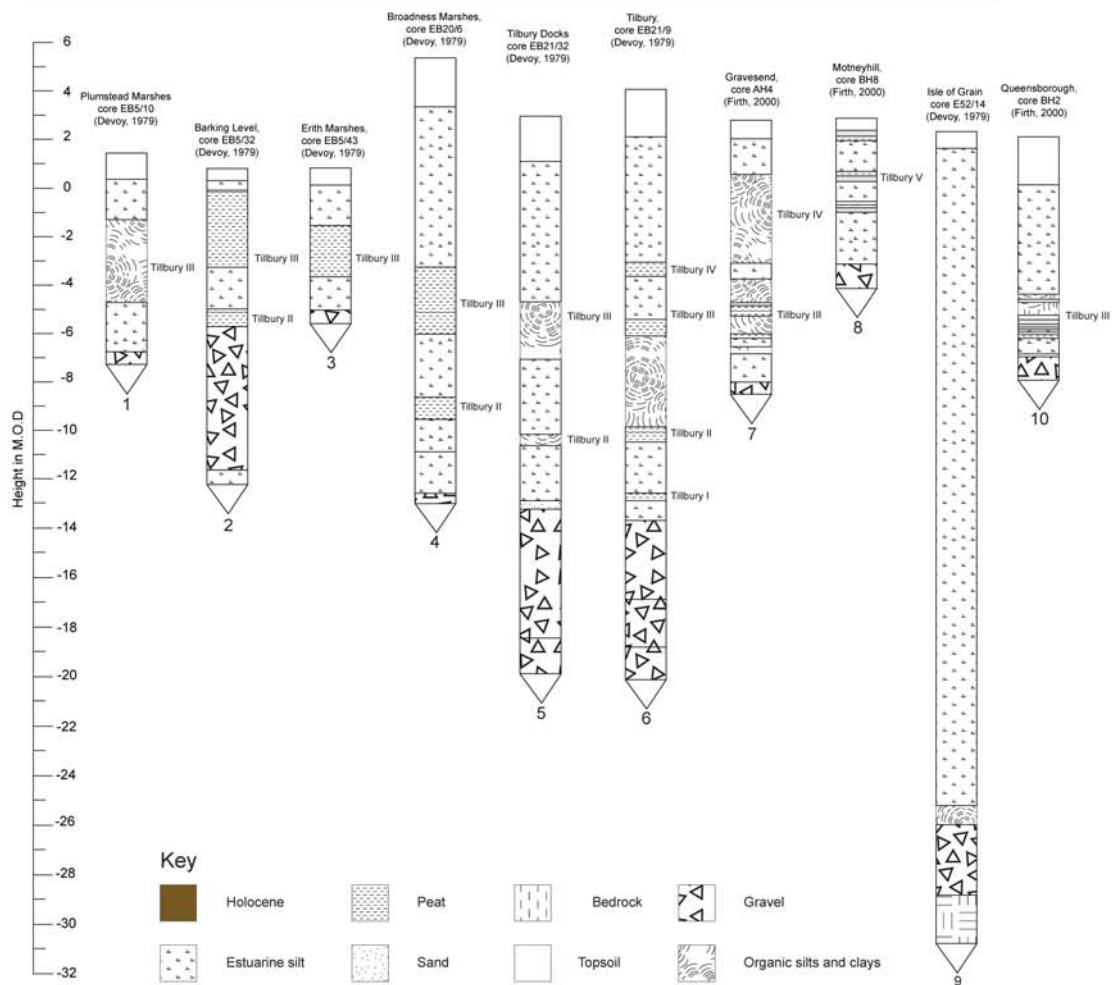
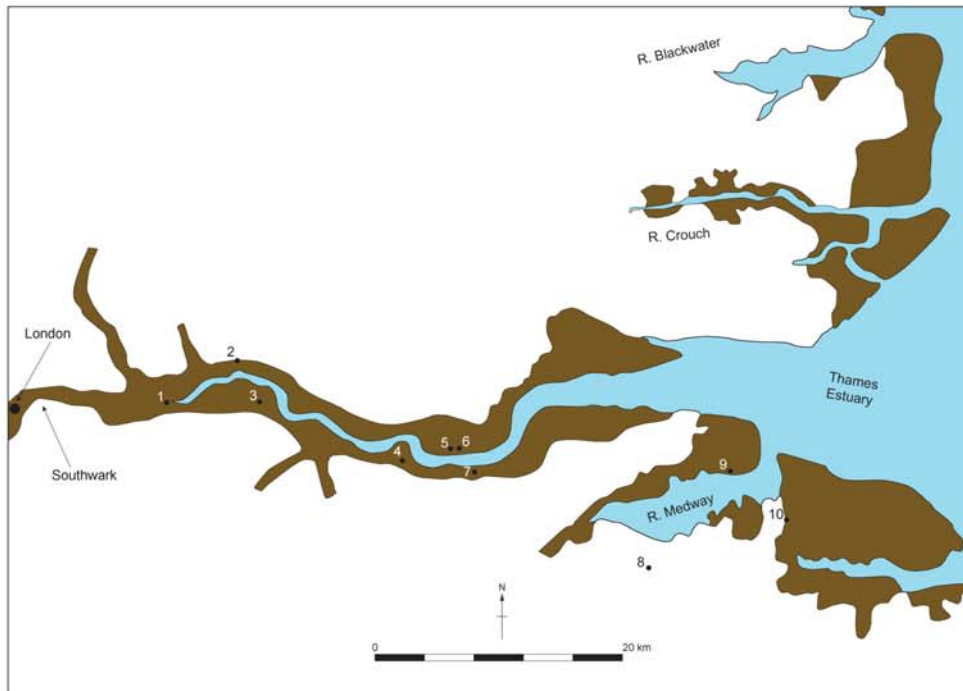


Figure 13: Holocene deposits of the Thames Estuary (after Allen, 2005)

5. DISCUSSION AND CONCLUSIONS

Sections 3 and 4 of this review provide a summary of our knowledge of pre-Holocene and Holocene marine sediments around the coast of southern England, focussing on the location, nature and age of the sediments and noting the key bibliographic references for each geographical area. This next section of the review identifies a number of themes that emerge from the summary and discusses the geoarchaeological significance and potential of the deposits.

The pre-Holocene sequences

It should be clear from this review that pre-Holocene marine deposits are rarely encountered around the coast of southern England, compared to their more-recent Holocene counterparts. These early deposits have been dated to the Pleistocene period using a range of techniques from altitude correlation to pollen analysis and luminescence dating. Accurate dating and correlation of deposits to specific interglacial periods remains a significant barrier to research. Few sites have yet been dated using independent techniques such as luminescence, and reliance on altitudinal correlation or pollen data tends to lead to circular arguments regarding the age of a particular site. This is evident in the studies described in Section 3.

A robust chronological framework is an absolute necessity if the geoarchaeological potential of pre-Holocene deposits is to be realised. However, regardless of the progress that will, no doubt, be made with chronologies, two underlying issues still place severe limits on that potential: the nature of the surviving deposits and the limited links that can be made to Palaeolithic archaeology.

Raised beach formations are the most commonly recorded pre-Holocene features and, as a result, are also the most widely studied. They are physical reminders in the landscape of previous interglacial periods when mean sea-level was much higher than at present. These formations can be seen intermittently along the southern coastline, but in Sussex they form major topographic features, such as the Norton-Brighton Raised Beach, which extends from Portsmouth to Brighton. Sediments associated with these raised shorelines are dominantly coarse-textured mineral materials (sands and gravels). These have little potential to yield palaeoenvironmental data, other than information about the physical characteristics of the beach environment on which they were deposited. Combined with good dating information, this will contribute to a growing understanding of sea-level change through the Pleistocene and therefore landscape evolution on a regional scale.

Of much greater potential value are the as yet rare occurrences of organic sediments, in locations such as Stone in Hampshire. These provide unique windows into coastal landscapes, which existed hundreds of thousands of years ago. In particular the organic deposits can be investigated for plant remains, such as pollen, seeds and wood fragments, from which environmental reconstructions can be made.

The study of pre-Holocene geoarchaeology is also severely constrained at present by the limited scope for Palaeolithic archaeology in the coastal zone. A few examples of relevant archaeological finds and sites were noted in Section 3 but, with the exception of Boxgrove in Sussex, these amount to very little. Pre-Holocene coastal geoarchaeology therefore tends to be an exercise in pure palaeoenvironmental studies with a limited contribution to the understanding of past human activity.

The Holocene sequences

In contrast to the pre-Holocene deposits, the review of Holocene deposits has shown them to be widespread and abundant along the southern English coastline. They largely consist of intercalated sequences of silts and peats, accumulating in low-energy environments within estuaries or behind sand and gravel bars. These complex accumulations of sediment reflect repeated and often rapid changes in the coastal environment, driven ultimately by varying rates of sea-level rise. The estuarine silt layers within the sequences correspond with periods when these localities became submerged by rising sea-levels, the peats forming when the accumulating silts reached the level of high tides. The different types of peats provide information on the nature of these emerging land surfaces, sometimes reed swamp, at others woodland or raised mire environments.

The archaeological potential

The importance of the coastline for human settlement is as relevant today as it was in the past. Many of our largest cities and towns are situated on the coast or tidal estuaries (London, Southampton, Bristol); these locations offer transport routes by boat across the sea or inland using river systems, important for communication and trade. They also offer resources for food: fish, sea birds and grazing for wild animals or domestic livestock, together with coastal plant resources. Today there are not many large areas of coastal woodland left but in the past these would have been widespread and provided fuel and construction materials. However, it is essential to bear in mind sea-level and stratigraphic information when we think of these coastal locations in terms of archaeological potential; sea-level was much lower in the past than it is today. This means that coastlines where people once lived, worked and travelled are now drowned landscapes, submerged by rising sea-levels and then buried by accumulating sediments. The archaeology of ancient coastlines may therefore be preserved and protected in accumulated marine sediments, many metres below the current surface.

The waterlogged nature of these deposits means they have excellent preservation conditions for wooden and other organic artefacts. Artefacts recovered from intertidal locations in the Severn Estuary range from the timber posts of Bronze Age buildings to wooden objects relating to activity in the Mesolithic (Bell *et al* 2001; Bell 2007). Such findings enhance our knowledge of how people lived in the past on the coast and the types of everyday tools and objects that were used, which do not generally survive in other (dryland) areas.

The palaeoenvironmental potential

Holocene marine sediments are valuable sources of palaeoenvironmental data, permitting the accurate reconstruction of the changing coastal environment throughout prehistory. Well preserved assemblages of pollen, wood and other plant macrofossils (seeds, buds) can be analysed to reconstruct the past vegetation of the area. Foraminifera and diatom analyses can show changes in sea-level and tidal windows, together with the fluctuations between freshwater and marine conditions. Insect analysis can also be utilised to look for the past presence of animals, past vegetation types and the activities of past people.

Pollen and other plant remains can provide valuable evidence for the composition of past woodland communities growing in the vicinity. In some locations the Holocene peats still contain extensive remains of actual woodland itself. These remnants of the former woodland are commonly referred to as 'submerged forests'. Through mapping and identification of these tree stumps and fallen trunks it is possible to record the detailed structure of an actual prehistoric woodland: whether they were closed or open canopied, whether they were wet carr-woodlands or dry oak dominated woodlands. This provides a remarkable opportunity to experience the past environment, rather than rely on complex pollen diagrams and graphical representations.

The intercalated nature of many of the deposits of silts and peats show that these areas were changing almost constantly. As Allen (2005) notes, such changes sometimes took place within a few decades rather than thousands of years. This means that the people living in these environments may have witnessed major environmental change in their own lifetime. Such changes would have had an effect on how these people lived and made use of this environment. The Holocene marine deposits can therefore offer a level of temporal and spatial resolution that permits reconstruction of environmental change on a human scale. Well integrated archaeological and palaeoenvironmental studies can yield histories of human/landscape interactions of a quality not obtainable in most terrestrial environments.

Are some areas being ignored?

The last 30 years has witnessed a high level of interest in Holocene marine sediments in the south of England, leading to the publication of numerous studies, some of which have been mentioned in this review. Research effort has not been uniform with attention focussed on two types of location: areas with high development pressure and areas with confirmed high research potential. As a result, for example, there has been a focus on development-led studies in the Thames Estuary and research-led studies in Romney Marsh. The Severn Estuary is noteworthy in receiving attention for both of these reasons with commercial developments triggering work on the Avon Level for example (Carter *et al* 2003; Locock *et al* 1998) and significant research-led projects on the Somerset Levels (Bell 1990; Haslett *et al* 2001). There is no reason to prefer either development-led or research-led studies; they represent complementary funding streams and, if well executed, both deliver high quality data.

In these well-researched areas there is now a good understanding of the regional chronostratigraphy and environmental history. Further work will therefore tend

increasingly to address local, site-specific, archaeological issues and will be triggered by local development-led agendas. This leaves a large number of other areas of Holocene marine sediments that have received little or no recent attention from geoarchaeologists. Typically these are relatively small areas of sediment in locations not affected by commercial development and include intertidal peat beds and submerged forests not studied since the 19th century. Caseldine (1980) lists a number of intertidal Holocene peats along the coastline of Cornwall where no substantive palaeoenvironmental work has yet been carried out. These small, poorly documented sites are unlikely to be the subject of development-led studies and are equally unlikely targets for researchers looking for suitable sampling sites.

A second type of bias can be identified if the location of sample sites within each area of Holocene sediments is considered. Most studies have taken place at locations that are now dry land with some extending into the present-day intertidal zone; very few have investigated sediments that are still permanently submerged. The explanation for this is partially the location of development pressures, which predominantly affect dryland sites, but there also severe practical difficulties associated with working below the high tide line. The result of this focus on dryland study sites is a bias towards sediment sequences that start in the mid-Holocene when relatively high altitude locations were first submerged by rising sea-levels. This is demonstrated in the abundance of basal peat dates around 6000-5000 cal BC. Most marine sediments of early Holocene date (c.10,000-7000 cal BC) still lie offshore; their location and extent are poorly understood and they are rarely encountered. The recent work off the coast of the Isle of Wight at Bouldner Cliff illustrates the existence of early Holocene sediments offshore, at least in sheltered locations, and their geoarchaeological potential. Work on submerged sites is potentially hazardous and relatively expensive, but it may be the only way to improve our understanding of the early Holocene.

Problems of erosion, coastal retreat and flooding

When reviewing the potential of Holocene marine deposits for further study, the urgency of such work needs to be considered in the context of coastal erosion. Many authors in their studies have spoken of this problem and the loss that it is causing to these deposits (Ratcliffe and Sharpe 1991; Housley *et al* 1999; Riley 2002). Exposures of deposits along the foreshore, such as at Minehead and Westward Ho! are extremely vulnerable to erosion by the tide (see Figure 14).

This problem is not just a local one, it is widespread and occurring now all around the coastline, but few studies have yet attempted to quantify rates of loss. At Brean Down, Bell (1990) measured the rate of coastal retreat by looking at section drawings from the late 1950's study and comparing ordnance survey maps of 1887 and 1971. The maps showed that in those 84 years between the drawing of the two maps, coastal retreat measured an average rate of 80mm/yr. However, the presence of a seawall is shown on the 1887 map. During the lifetime of this wall, coastal retreat would have been reduced and Bell (1990) suggests that over the period spanning the excavations of the late 1950s and his own excavations in the mid-1980s rates of erosion were much higher. Estimated rates of erosion on the area of the archaeological deposits suggest they are now approximately 10m further inland than they were in the 1950s excavation. These

calculations show a remarkable rate of coastal retreat occurring at Brean Down, which is likely to be continuing to the present day.

These deposits then need to be viewed as diminishing resources, which will not be present forever. Indeed, as present sea-levels continue to rise, more exposures higher up the foreshore and cliff faces will be affected by erosion. Many of the exposed and therefore threatened deposits were only studied during the late 19th and early 20th centuries. Therefore they have not benefited from more recent sampling methods and analytical techniques. If we are going to make the most of these eroding resources while they are still available a similar boom in research effort is needed.

Some protection to these deposits may come from new work in coastal management, particularly through managed retreat of the existing coastline for the protection of present-day areas of saltmarsh, such as that proposed by English Nature. This will protect some of the existing deposits from erosion as they become submerged and allow new sequences of estuarine silt to accumulate over them. They may become less accessible in the future but the sediments, and the information that they contain, will survive.



Figure 14: The surviving peat inner area at Westward Ho! (photograph provided by Dr S Buckley)

Future research priorities

Rather than compiling a long list of detailed recommendations for future research, two high-priority topics for future research in pre-Holocene and Holocene deposits are propose.

Pre-Holocene

Research in pre-Holocene deposits is greatly hindered by the lack of a strong chrono-stratigraphic framework for marine sediments in southern England. This should be addressed through a co-ordinated dating programme for key stratigraphic sequences. This may involve the re-examination of 'classic' sites and the critical testing of long-standing interpretations. At Portland, Davies and Keen (1985) illustrated how the conclusions of early studies can become entrenched in the literature and delay advances in our understanding.

Most published studies of pre-Holocene marine sediments have been undertaken as exercises in palaeoenvironmental research and there has been little attempt to develop an explicitly geoarchaeological approach to these deposits. This reflects the paucity of archaeological material and lack of direct associations between archaeological sites and contemporary marine sediments (a strong contrast with the Holocene deposits where links are strong). The archaeological work at Boxgrove indicates what is possible, given the right site. It has provided insight not only into the environment of these early people but also the way they lived and interacted with that environment. It is not anticipated that such sites are common or will be readily identified if searched for. However, progress can be made given a systematic approach, as demonstrated by the advances in understanding of Palaeolithic archaeology in the fluvial sediments of southern England. Greater collaboration is therefore recommended between geoarchaeologists and Palaeolithic archaeologists to explore the potential for a geoarchaeological contribution to Palaeolithic studies in the coastal zone.

Holocene

Both recommendations for action on Holocene marine deposits reflect concern over current bias in research effort and the consequent gaps in our knowledge, both geographical and chronological.

Chronological bias should be addressed by an increased investment in the exploration of off-shore deposits that should include early Holocene sequences, largely missing from the well-researched dry-land sequences. The development of new survey techniques (remote sensing in particular) and advances in sampling equipment mean that previously inaccessible offshore locations are now becoming easier to study.

Numerous exposures of Holocene marine sediments around the coast of southern England are only known from short accounts in 19th or early 20th century publications. It has been assumed that these apparently small, isolated sequences are of limited research value and they have been largely ignored. The potential of these deposits is poorly understood at present and should be addressed through a targeted programme of sampling, dating and assessment. It is recognised that some of the requirements of this recommendation will be met by the programme of Rapid Coastal Zone Assessments (<http://www.english-heritage.org.uk/server/show/nav.18390>). This work is particularly urgent given the evidence for ongoing erosion of these sediments in the present intertidal zone.

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