Geology and coastal change

Chichester Harbour lies within the Solent River system that is dominated by Cretaceous Chalk and overlying muds, sands and gravels of the early Tertiary deposits. A natural basin has been created by relatively gentle deformation of these deposits over geological time. The river system developed during the Pleistocene, and has been significantly altered by every glacial highstand, most recently with the Holocene transgression which has flooded the lower reaches of the Devensian system (Dix in Wenban-Smith and Hosfield 2001). Lower and Middle Palaeolithic artefacts are associated with the underlying geology, and these are discussed later.

The Solent and surrounding estuaries and inlets have incised into the Mesozoic and early Tertiary rocks of the Hampshire basin that formed part of the Anglo-Paris-Belgian basin. The seas transgressed and regressed in response to eustatic fluctuations and localised subsidence. The Cretaceous in this area is dominated by the Lower, Middle and Upper Chalk, of which the Campanian Upper Chalk dominates and outcrops at the head of the Chichester inlets amongst others. The basal unit of the Tertiary sequence are the Palaeoene Reading Beds, above which are red-mottled clays and sediments of the Palaeocene-Lower Eocene London Clay unit that consists of silty and sandy clays, clayey silts and sandy silts and is overlain itself by sands, clayey sands and sandy clays.

The Pleistocene geology is dominated by the development of the west to east flowing Solent River System. Gravel deposits throughout the area represent successive phases of fluvial deposition.

Human beings first appear in the archaeological and geological record about half a million years ago. Since then, the coastline of Sussex and the winding creeks of Chichester harbour have undergone enormous changes. During this time there have been vast changes of climate and in particular a series of alternating cold glacial and warmer interglacial periods. Although the ice never reached as far south as Sussex, its proximity had a profound effect. At the height of a glaciation the great volume of water locked up in ice sheets and glaciers around the world would have dramatically reduced sea-levels, at times by over 100 metres, whilst the weight of the ice would have caused the land mass to be depressed. The extremely cold periglacial conditions would have produced thick sheets of soliflucted gravels. These were laid down as a result of the mass-movement of semi-frozen rock and underlying deposits down the slopes of the Downs on the coastal plains, into the river valleys and onto the floor of what is now the English Channel.

Before examining in detail the archaeological evidence for the AONB, it will be worthwhile to give an overview of the effects of sea level rises and coastal change. These processes were a key determining factor to human activity in the AONB.

Prior to the Anglian glaciation about 480,000 years ago, the eastern part of Sussex was joined to the continent by a substantial land mass that was eventually breached by water overflowing from an ice-dammed lake in the southern North Sea. The rivers that cut through the Sussex Downland today represent remnants of much larger river systems that originally flowed into an embayment south-west of this early land mass and later into a postulated Channel river, flowing south of the present Sussex coastline.

Some 13,000 years ago during the last major glaciation an ice sheet over 1km thick covered north-west England and Scotland. As climatic conditions improved, hunter-gatherers were able to cross to Britain on the bed of the North Sea, left largely dry because of the volume of water frozen in the glaciers. As the ice melted and the sea level rose, the river valleys began to flood while the land rose under the decreasing weight of the ice mass. Sea levels rose rapidly during the Mesolithic and into the Neolithic, leading to a continued alteration of the coastal environment. By about 8,000 years ago the land mass had disappeared and Britain was separated from the continent by the Channel. Coastal sites from this period will lie far off-shore – attested by finds of flint axes and barbed harpoon points dredged from the floor of the North Sea.

Rising sea levels would have flooded the lower reaches of the AONB, while wetter fresh-water conditions would have been encouraged further up the river valleys, leading to peat growth. Peat is important because it not only provides a picture of vegetational history, but also indicates the nature and chronology of sea-level rise and coastal change, especially when the peats are interleaved with inorganic marine silts and clays.

The shape of the early coastline would have been strongly influenced by the topography of the drowning landscape. However, the reconstruction of past coastlines is complicated by a number of factors and cannot be achieved simply by dropping former sea-levels on the underlying topography (Woodcock 2003). The factors to take into account include the topography of the landscape prior to the sea level rise, the geology of the coastal environment, the availability of gravels and sediments on the floor of the Channel that may have been redeposited in the coastal zone, the effects of tidal flow and of periods of storms, and sediments redeposited from the land and human intervention. The former land surface may also have suffered attrition and erosion.

Erosion along the Sussex coast is well documented – for example Selsey extended considerably seaward of the present coast. However, it is not clear how far back in time this rate of erosion can be extrapolated. The history of the Sussex coastline is dominated by the formation and migration of coastal and off-shore barriers. These sand and gravel deposits can migrate landward under the influence of rising sea levels. In the early Neolithic period, the coastline would have been deeply indented, perhaps with sandy beaches and barriers close inshore. Most river estuaries would have been broad and tidal. More substantial coastal shingle barriers would have formed as the sea level began to stabilise. West of Selsey peninsula, the direction of longshore drift is westward (the opposite direction to the rest of the Sussex coast, in fact). This, and the sheltering effect of the Isle of Wight, meant that Chichester Harbour has managed to escape the most profound effects of barrier formation and consequent silting. The pattern of sedimentation in low-lying areas can be partially explained by the rate of sea-level change slowing down, although the formation of barriers and spits often depends on local rather than regional circumstances. These circumstances include the distribution, thickness and nature of the sediments and how easily they might be moved by longshore drift, influenced by the direction and strength of tidal flow, coastal currents and the effects of climatic deterioration and severe storms.

Sea level appears to have stabilised by the Early to Middle Bronze Age, but by the end of the Late Bronze Age marine influence extends up the river valleys, indicating a period of dramatic change. The depletion of the barriers, perhaps due to climatic deterioration and increased storminess, allowed the sea to flood right up the lower reaches of the rivers and their estuaries. This turned former marsh, meadow and fen into tidal salt-marsh to produce and environment that is similar to Chichester Harbour today.

The highly indented coastline remained a constant feature through the Iron Age and Roman periods. Sea level during these times was some 1 to 2 metres lower than the present day. As longshore drift continued, this may have restarted the process of barrier building encouraging silting that may have allowed land reclamation to take place. Shingle bars would have continued to form into the early medieval period across the broader embayments of former marshland. The silting of the former salt marsh would have been ideal for the extraction of salt and reclamation as silting continued.

Other changes in the coastal morphology occurred more recently. Historical accounts suggest a period of increased storminess at the end of the 13th century. There may also have been a slight rise in sea level – numerous documents attest to the difficulty of water control and maintaining the walls that kept the sea at bay. Severe storms and associated flooding continued into the 14th century which contributed to the abandonment of some arable fields and their reversion to pasture.

Some of the most dramatic changes in coastline in historic times have been at the mouth of the Harbour (Fig 2). East Head has shifted dramatically in the past 250 years (Searle 1975), retreating progressively east since the late 18th century by over 500m. This process may have been accelerated by the building of groynes along the beaches to the east in Bracklesham Bay as far as Selsey Bill that have starved East Head of the material required to sustain it.

A study by Wessex Archaeology used historic maps to plot changes in the coastline of Hampshire, part of which is included in the AONB (Beatie-Edwards and Webster 2002). Only the period from 1843 onwards was mapped since charts and maps of an earlier date were found not to be of the required accuracy. The main sources used were OS maps; the High Water and Low Water marks were used to plot coastal change. Even this proved to be challenging, not least because the very definitions of high and low water have changed over time. The study found that there was a considerable landward movement in the high water mark of the south-eastern coastline of Hayling Island. The shift between the 1st and 4th editions OS (mid to late 19th century to mid 20th century) was over 80m north. The study also found a dramatic growth in salt marsh area between the early 20th century OS mapping and the modern period. In Chichester Harbour along the coast of Hayling Island during this period the inter-tidal zone becomes categorised as ‘marsh’ rather than ‘mud,’ suggesting salt marsh accretion is taking place.

The movement of spits was also identified, defined as a shift in location rather than a gain or loss of area. The development of spits can be indicative of depositional coastal processes, and the erosion of some spits can be attributed to the creation of sea defences halting the supply of depositional sediment required for their maintenance. Black Point spit on Hayling Island has undergone movement of both the high and low water marks. This lateral shift in the position of high water is as much as 40m in a westerly direction between the 1st edition OS (1843-1893) and the 4th edition OS mapping (1919-1943), the study found. The head of the spit also underwent growth in this period, although this action can probably be attributed to the development of the area rather than natural deposition.

Deliberate reclamation can have the effect of pushing the recorded high water mark seawards. Small areas of widening include Sandy Point on the south-east tip of Hayling Island, a process that has taken place between the early 20th century OS maps and the modern OS mapping. Hooke and Riley (1991) suggested that between 1870 and 1965 the inter-tidal zone has decreased in area by 50% or more in some locations. This percentage is likely to have increased again between 1965 and the present. The natural changes, in the form of coastal erosion and accretion, the movement of spits and inter-tidal / offshore changes have a greater effect along the more exposed areas that are subject to powerful marine forces, like Hayling Island.

Coastal change has had an inevitable effect on the use of the AONB as a harbour. The establishment of a naval base was rejected by the Navy Board in 1698 because the harbour was 'too dangerous to enter.' At this time the entrance to the harbour was barely a quarter of a mile wide. An Admiralty chart of 1845 shows a sounding of just two feet in places at Mean Low Winter Springs. Entry to the harbour seems only to have been possible form half-tide onwards, with a pilot steering many non-local vessels.

The spur of land to the south of Chidham Point has migrated slightly north. When the 1st edition OS map was drawn the spur was centred at about 477860 103785, with a swirl of gravel just to its north. An extensive sandbank at Ferry Barn to the west of Furzefield Creek shown on the 1st edition OS map has reduced in size, although a path on the top of the bank running south to West Itchenor – marked 'Hard' on the OS map is still in use today.

Channels have also altered over time. A channel shown on the 1st edition OS branching from Sweare Deep at 473700 104280, heading for Emsworth and then curving to the west and meandering to Conigar Point has disappeared from the modern mapping.

Attempts to control coastal change and to restrict the flow of the sea have met with varying success in the harbour. The most successful reclamation of land was in the 19th century when the north part of Thorney was enclosed. Sea defences were largely in place on the vulnerable west coast of Thorney by the time of the 1st edition OS map. At Conigar Point, an embankment was also in place, although this did not prevent the loss of irregular area of marsh and a sand bank. An embankment around Chidham Point was later extended north by a sea wall up the northeast coast of Chidham. A gap in the sea wall on the east coast of Chidham at Cobnor House may have been a landing place.

There were the remains of a possible quay at Cobnor Hard, on the east coast of the Chidham peninsula. These consisted of 'stumps … still visible in the mud in front of the boathouse' (Anon ?1960s).

A sea wall running from the west of Cobnor Point on Chidham to Pilsey Island shown on the 1st edition OS represented an ambitious but failed attempt to exclude the sea from Thorney Channel. A further attempt to enclose the bay south of Prinsted with a sea wall also failed. These walls – or 'cuts' – can still be seen, for example on aerial photographs (see below).

There are great differences between the smooth coastline of the present day and the deeply indented inlets of the Neolithic, the fen covered peat valleys of the Bronze Age, the inundated coastline of the Iron Age and Roman periods, and the reclaimed coast of the medieval period. Understanding coastal change can lead to predictions of where archaeological sites may survive, as well as to an understanding of how such processes affect sites that are already known. A study of past environmental changes not only provides a background against which present coastal zone management can be set, but also provides a basis for predicting how the coastline might develop in the future.

Research questions

Research should be focussed on understanding coastal change through time, building on the work already done. An understanding of coastal change will aid future management of the Harbour by improving knowledge of past and current processes which in turn might aid the prediction of future change.

A major contributor to coastal change has been changes in sea level. Investigations into relative sea level change could lead to the production of broad period maps showing major channels, islands, promontories and coasts for different major periods.

There is a need to assess the condition of all sites recorded for the AONB on the Sites and Monuments Records (SMR) held by local authorities. This field assessment should be aimed at identifying known and potential risks posed by sea level rise, natural erosion, changing land use and other threats. Such work would ensure that these sites are recorded as fully as possible before archaeological evidence is lost.

A similar assessment of sea defences could also be undertaken to determine their age and current condition. The position of quays and sea defences is critical to an understanding of the harbour and how these have impacted on the changing distribution of sediments around the area. A full study of the relevant maps and charts could be a topic for future research.

Future research should also aim to continue to map and date sand and gravel deposits and to develop understanding of Pleistocene deposits in the AONB.

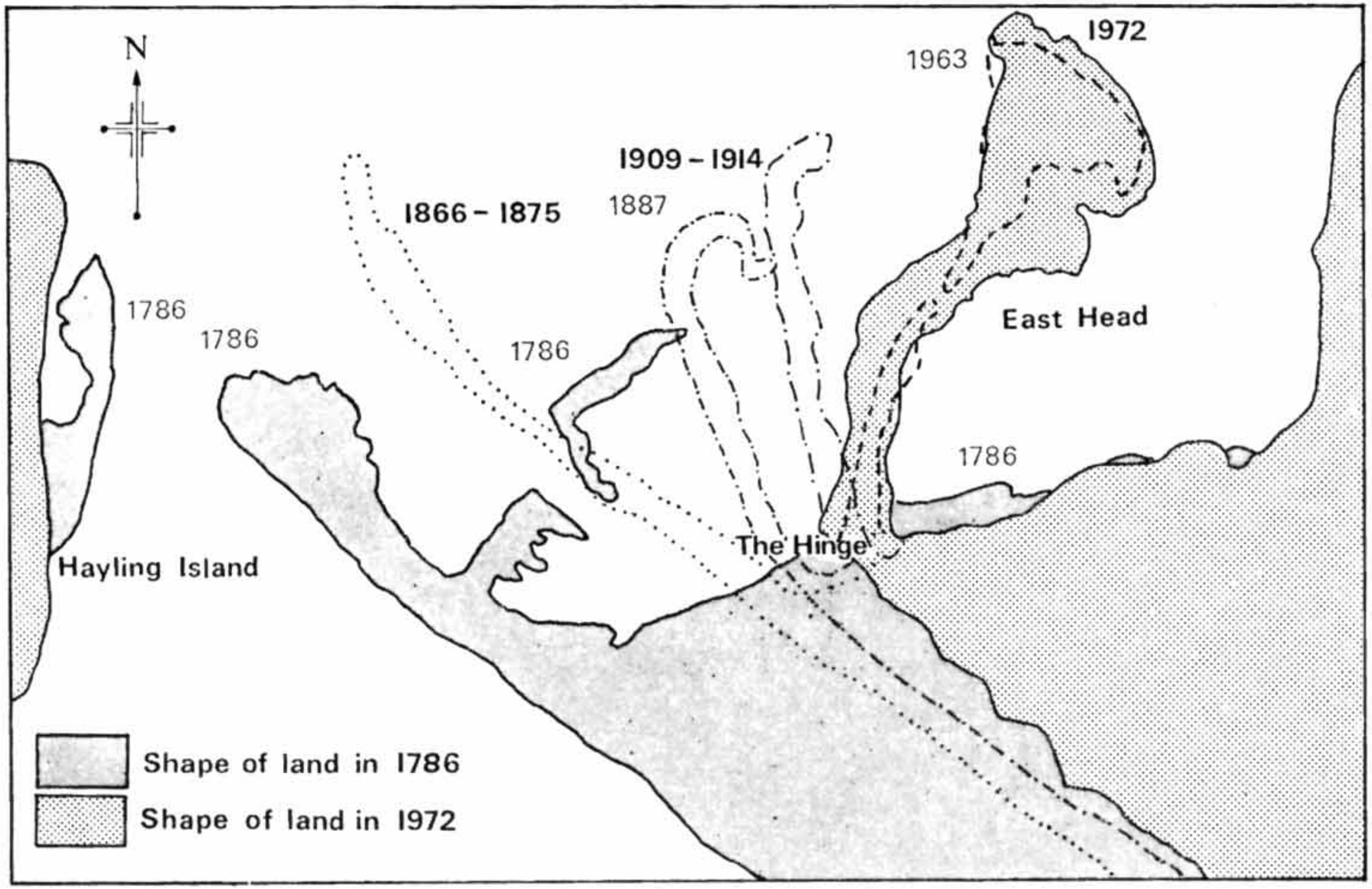

Fig 2 Changes in the shoreline in the East Head area since 1786 (in Seale 1975)

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