PAGHAM HARBOUR

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OS Grid Reference: SZ880960

Introduction

Pagham Harbour (see Figure 6.2 for general location) is the easternmost of a series of drowned river valleys and shallow estuaries that characterize the coastline of southern central England. They include Poole Harbour in the west, the Solent, and Langstone and Chichester harbours. With the exception of the Lymington River and the Medina estuary at Cowes, they all have sand or shingle spits at their mouths, and many are distinguished by double spits extending from both sides of the estuary. The shingle spit across the mouth of Pagham Harbour comprises a series of sub-parallel shingle ridges and recurves, which mark different phases of extension and accretion. Shingle reaches the beach via the intertidal zone. The behaviour of the spit and the so-called 'Pagham Delta' (an area of deposition associated with the mouth of the estuary) are intimately linked with water and sediment circulation around the Selsey peninsula. The area also provides an excellent example of the role of weed-rafting of shingle in coastal sediment budgets.

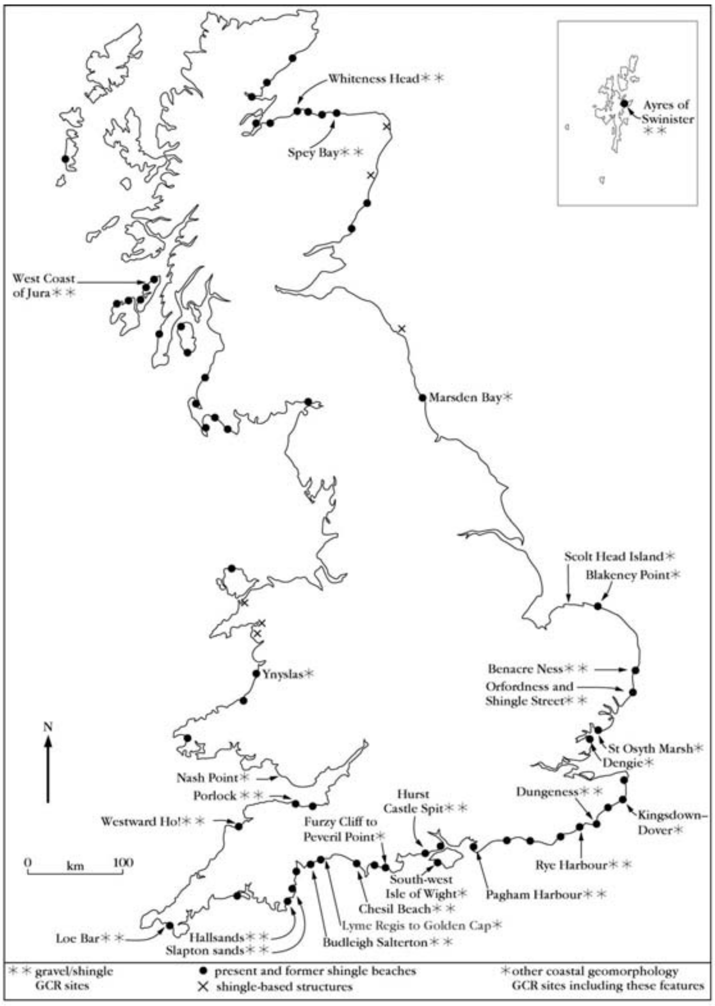


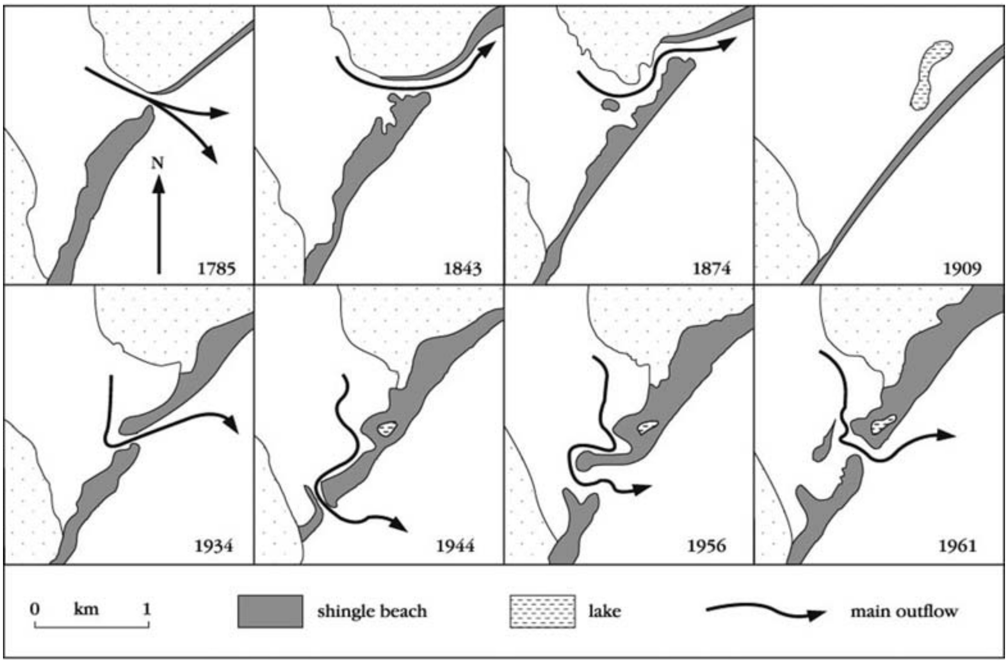
Figure 6.2: Coastal shingle and gravel structures around Britain, showing the location of the sites selected for the GCR specifically for gravel/shingle coast features, and some of the other larger gravel structures.

Ward (1922) and Steers (1946a) described the main features of the development of the estuary and the spit; Robinson (1955) compared the development of the Pagham site with the spits at Christchurch and Poole. Kidson (1963) challenged the hypothesis for double spit development. May (1964) showed how the spit had developed over a period of several years. The development of double spits is not uncommon at the mouths of shallow estuaries, but Pagham Harbour is distinguished by having changed from spit to bay-bar to spit again. Its double form is probably a result of breaching rather than a result of opposing directions of longshore sediment transport. The supply of shingle to the spit has been and continues to be dominated by transport from the direction of Selsey Bill (Harlow, 1979; Hooke *et al.*, 1996), supplemented by kelp-rafted pebbles (Jolliffe and Wallace, 1973).

Description

The site comprises a shingle beach that extends from the east side of Selsey Bill (SZ 870 941) to the Pagham Beach Estate (SZ 895 975), part of the Pagham Harbour estuary, and its extensive intertidal gravels. The intertidal gravels occur as irregular extensions of the beach at Inner Owers and a bank known as 'The Spit', but form a distinctive delta-like form at the mouth of Pagham Harbour. At Church Norton, the beach is formed by a number of ridges or 'fulls' (as they are called locally). Shingle is characteristically larger locally on the ridges. The shingle spit extends across the mouth of the estuary, with a series of short recurves marking periods of advance. The estuary forms the easternmost part of a valley system which extends to the west of Selsey Bill where it has been truncated by the retreat of the coastline and is now only prevented from periodic inundation by a shingle ridge. In 1910, this western ridge was breached and the sea flowed through the low-lying land into Pagham Harbour, breaching the shingle ridge, which until then completely closed the harbour entrance.

The present-day spit across the mouth of Pagham Harbour is a much smaller version of a longer feature that grew north-eastwards from at least the mid-17th century and gradually forced the outflow from the estuary farther towards Pagham, until it was breached in 1910. By 1934, two separate ridges extended from each side of the estuary. The intertidal gravels diverted the outflow towards the north-east, but ten years later the outflow was located at the south-western end of the southern ridge (Robinson, 1955). This spit gradually decayed and was replaced by a newer structure that grew from the south-west (Figure 6.23). This not only diverted the outlet north-eastwards but also changed the wave patterns within the entrance to the harbour and thus the alignment of the decaying former spit.



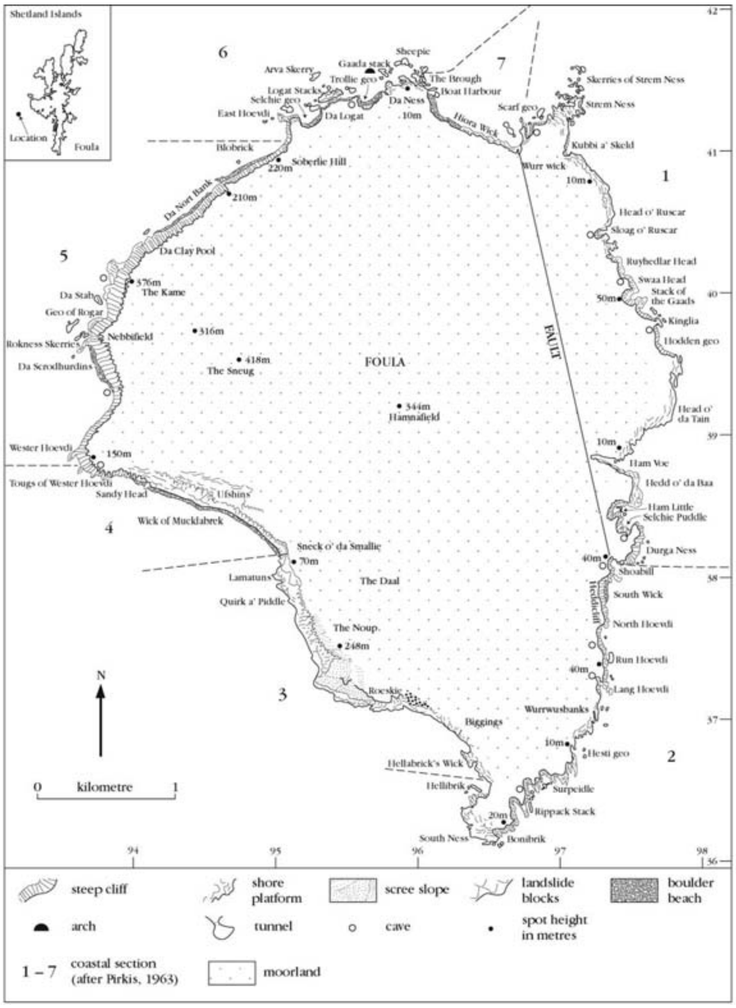


Figure 6.23: Historical changes at Pagham Harbour 1785–1961. (After Robinson, 1955.)

The intertidal area at the harbour mouth extends over 800 m seawards and is largely composed of gravel locally derived. The outflow from the harbour appears able to maintain a channel through these deposits. The intertidal area has had much the same width throughout its history, but both the outlet and the form of the delta have altered their positions. Thus, as the spit has changed its shape, so it has affected the form of the intertidal area. As a result, wave refraction has also altered.

Severe erosion along the eastern side of Selsey Bill has meant that the present area of the harbour mouth has been exposed increasingly to waves approaching from the south. The limited documentary evidence suggests that Selsey was connected to the mainland only on its south-western side at Medmerry. Gradual silting of the harbour and its land-claim was associated with the growth of the beach across the mouth of the harbour by 1909.

Interpretation

Steers (1946a) noted the different sized spits, the larger extending from the south-west, the much smaller from the north-east. He suggested that they appeared similar to the opposing spits at the mouth of Poole Harbour and were probably of similar origin. It was not clear, however, if a local counter-movement of shingle from the north-east was responsible for the smaller spit. Robinson (1955) considered the double spits not only at Poole and Pagham, but also at Christchurch. From a detailed consideration of cartographic and field evidence, he argued that the spits resulted from unidirectional drifting followed by breaching. This model depends upon longshore transport that forms, maintains and usually extends a spit across an estuary and also diverts the river outflow. At Christchurch and, Robinson believed, elsewhere, wave and river conditions would bring about breaching, such that the distal end of the spit would eventually be attached to the mainland and its proximal end modified so that it assumed the form of a spit. At Pagham Harbour (Figure 6.24), it can be shown that the spit has normally grown from the south-west fed by the very large quantities of material eroded from the cliffs at Selsey. Between 1956 and 1961, such a phase of growth was accompanied by gradual decay and transgression of the former north-east spit on to the saltmarsh within the estuary (May, 1964). Although Kidson (1963) challenged the general applicability of Robinson's unidirectional view, he acknowledged that in some areas growth was predominantly from one direction and that, since breaching could be shown to have taken place, attached beaches could co-exist on both sides of an estuary. Robinson's discussion focused on Poole Harbour as well as Pagham Harbour, and the debate is covered more fully in the description of South Haven Peninsula GCR site in Chapter 7 of the present volume.

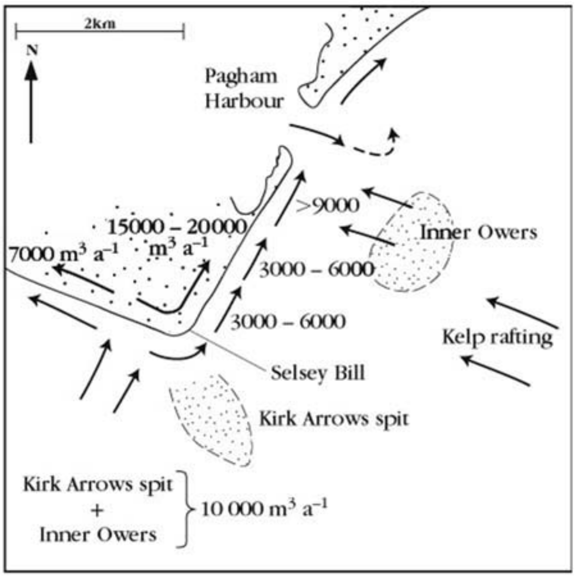


Figure 6.24: Sediment pathways at Pagham Harbour. Arrows show sediment pathways with estimated annual volumes. (Based on Lewis and Duvivier, 1976; Hooke et al., 1996; and Harlow, 1979.)

Davies (1972, p. 140) suggested that 'discussion of apparently anomalous inlet locations on the British coasts for instance (Robinson, 1955; Kidson, 1963) may possibly have been clouded by lack of consideration of the swash deflection process'.Bascom (1954) argued that, on beaches where drift is minimal, the position of inlets is determined by berm height. This in turn is determined by the distribution of wave energy along the beach. Where wave refraction is greatest, the berm is lowest and therefore a breach is most likely. At Pagham, there is considerable refraction of long waves crossing the delta with the result that at high tide they approach the beach from a more south-easterly direction than at low tide. Nevertheless, drift is considerable. The mechanism proposed by Bascom does not appear to apply here because drift is substantial, and berm height has tended to be lowest towards the distal end of the spit.

Until the construction of coast protection works at Selsey Bill in the late 1950s, erosion of the emerged ('raised') beach deposits had contributed about 4000–5000 m^3 sand and shingle annually to the westwards drift (Harlow, 1979). Larger amounts probably travelled towards Pagham. With annual cliff retreat in excess of 6 m a^{-1} between 1932 and 1951, the eastern cliffs at Selsey Bill were probably supplying about 9000 m^3 a^{-1} to the beach leading to Pagham. Jolliffe and Wallace (1973) described a process in which kelp-rafted shingle was trapped by the seabed off Selsey Bill. Two small denuded anticlines are the focus of shingle accumulation. Clasts travel up the gentle dip slopes, and are prevented from escaping by the ratchet-like scarp slopes of the individual beds. Shingle is then moved by wave action along the strike of the beds, to arrive ultimately on the beach. Harlow (1979) estimated that about 1000 m^3 a^{-1} is added to the westward drift from Selsey Bill by this mechanism. The division of longshore transport at Selsey Bill probably means that shingle also travels towards Pagham from this source. Hooke *et al*. (1996) show that between 3000 m^3 a^{-1} is added by wave-driven onshore transfers to a longshore component of a similar magnitude. There is some kelp-rafting as well as some transport seawards from within the estuary. The rate of longshore transport east of Pagham was not quantified by them. It is likely to have diminished considerably as a result of the construction of groynes between Selsey Bill and East Beach (SZ 874 948). Storm waves, for example during early January 1998, have overtopped the shingle ridge and moved the main crest landwards.

The historical evidence for the Pagham site demonstrates that a double spit form can result from unidirectional sediment movement. Breaching of the spit, nevertheless, produced a feature upon which the smaller-scale structures, for example small recurves, are a result of local longshore movement contrary to the general regional pattern. Thus the larger feature is the result of one set of processes, but its detailed form is a result of the modification of the smaller-scale processes. The importance of different time and spatial scales is well exemplified by the site. Pagham spit is the best-documented member of a considerable number of small paired spits in southern England, which together enhance our understanding of estuary-mouth sediment dynamics. It is the only such site where the sequence from unidirectional shingle spit to breaching and the resultant formation of a double spit have been documented definitively. In other cases, one spit has been described but the other ignored (e.g. at the mouth of Chichester Harbour), or there has been no investigation at all (e.g. the spits at the mouth of Newtown Harbour on the Isle of Wight), or coast protection works have radically altered one or both of the spits (e.g. Christchurch Harbour). As a bay-bar, it was a comparable form to the Loe Bar (see GCR site report), but unlike the latter was dominated by strong longshore sediment transport. In contrast to other double spits in England and Wales where sand is the main sediment, Pagham spit is formed predominantly of shingle. The development of shingle ridges has allowed the extension, breaching and repositioning of the detached ridges to be traced with greater certainty than is possible with sandy structures. Pagham Harbour thus adds considerably to the understanding of spit development.

Conclusions

Well known for the double shingle spit, Pagham Harbour is an excellent example of spit growth and breaching associated with both longshore and offshore sources of sediment. Today the natural sediment supply has largely ceased as a result of anthropogenic influence, but the ridge patterns preserve the earlier history well.

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