GIBRALTAR POINT

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Introduction

The Gibraltar Point area covers a wide range of types of accretion on a coast of low topography. It is one of the few stretches of relatively natural coastline on the east coast of England between the Humber and the Wash (see Figure 8.2 for general location). It has been studied in detail over several decades, the initial surveys being carried out over 50 years ago (Barnes and King, 1951). It illustrates very clearly the interaction of tidal and other coastal processes in a complex and actively developing environment. It provides a very important contrasting site in similar tidal and wave conditions farther north at Spurn Head, Yorkshire. The features include intertidal sandbanks offshore, a well-developed ridge and runnel foreshore, a spit, sand dunes and saltmarshes (see Figure 10.4) in various stages of evolution (Barnes and King, 1953, 1955, 1961; King and Barnes, 1964).

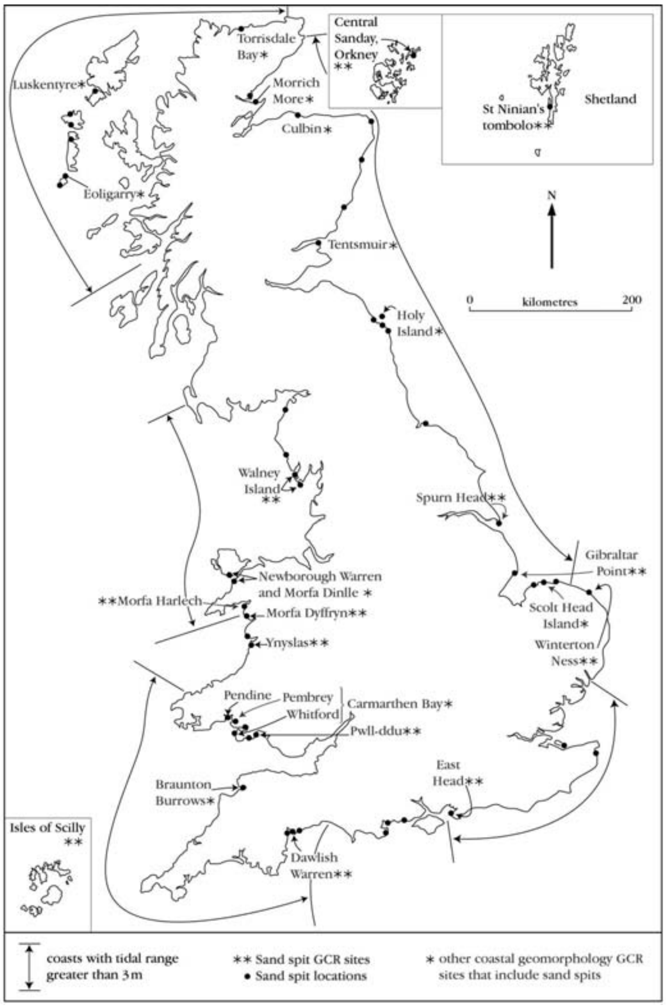

Figure 8.2: The location of sand spits in Great Britain, also indicating other coastal geomorphology GCR sites that contain sand spits in the assemblage. (Modified after Pethick, 1984).

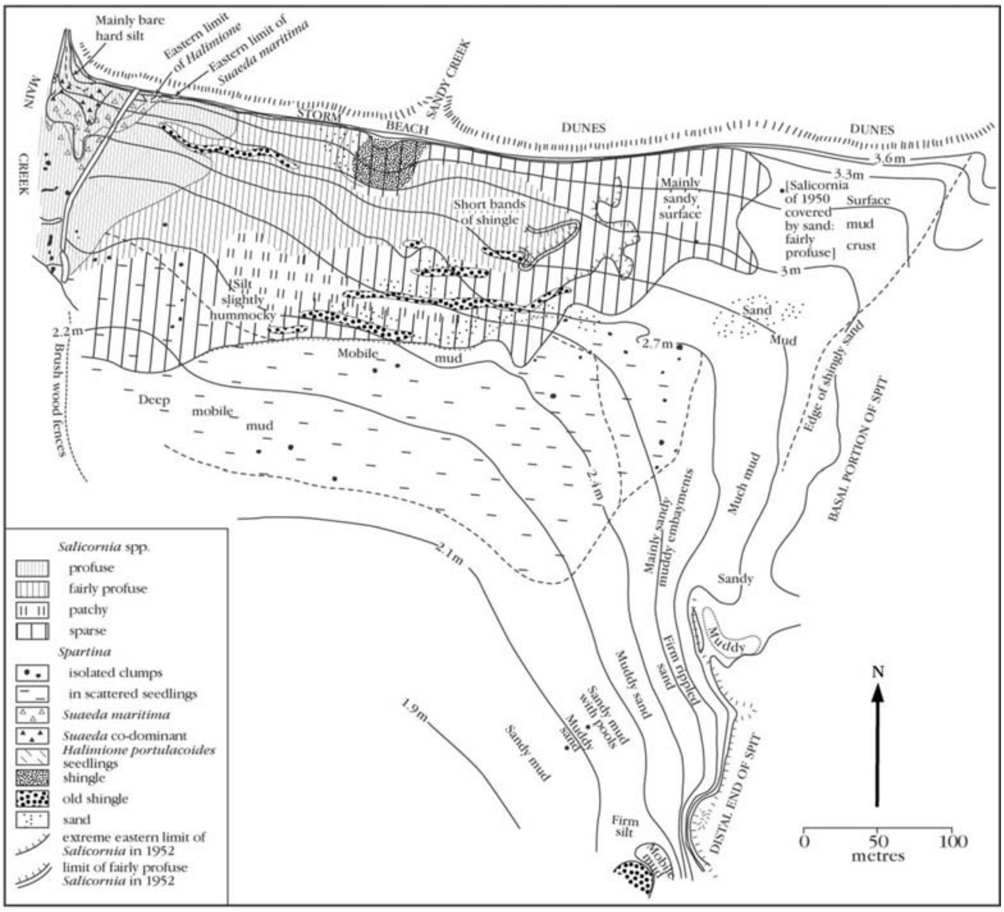

Figure 10.4: Map of the saltmarsh at Gibraltar Point, Lincolnshire, recording the position in 1951. The marsh was growing on the landward side of the spit; the area was re-surveyed in 1959, by which time 15–30 cm of sediment had built up the marsh surface over most of the area, and the low-lying mud and sand of 1951 had been colonized by common cord-grass Spartina. (After King, 1972a, p. 428.)

Description

The nearshore zone in this macrotidal environment, where the spring tidal range is over 7 m, is dominated by intertidal sandbanks, including tidal stream ridges and tidal deltas (Davies, 1963). These features are connected with the movement of sediment to the foreshore, which is characterized by a well-developed ridge-and-runnel beach. The ridges and runnels, which are built by waves, lie at a slight angle to the shore, diverging from it southwards. The ridges are composed of sand, but mud can accumulate in the sheltered runnels. Towards the top of the foreshore, the ridges become stabilized and are converted into foredunes by the addition of windblown sand accumulating around sand-loving vegetation. The growing dune ridges are separated by marsh slacks. Saltmarsh vegetation plays an important part in the development of the slacks. Farther inland, beyond the reach of the high spring tides, mature dunes form the backshore zone.

At Gibraltar Point, the coastline turns sharply south-westwards into the Wash and the upper foreshore ridge prolongs the beach line as a short spit. This spit has provided shelter behind which a new saltmarsh is forming (Figure 8.12). This demonstrates clearly the stages of marsh development in a macrotidal area with a good supply of fine sediment available. The New Marsh is separated from a mature marsh by a storm beach, a feature that illustrates well the importance of the occasional extreme event in the development of a low coastline of this type. It was the result of a storm surge in 1922 that truncated the mature dunes at their southern end and the mature marsh that had grown in their shelter.

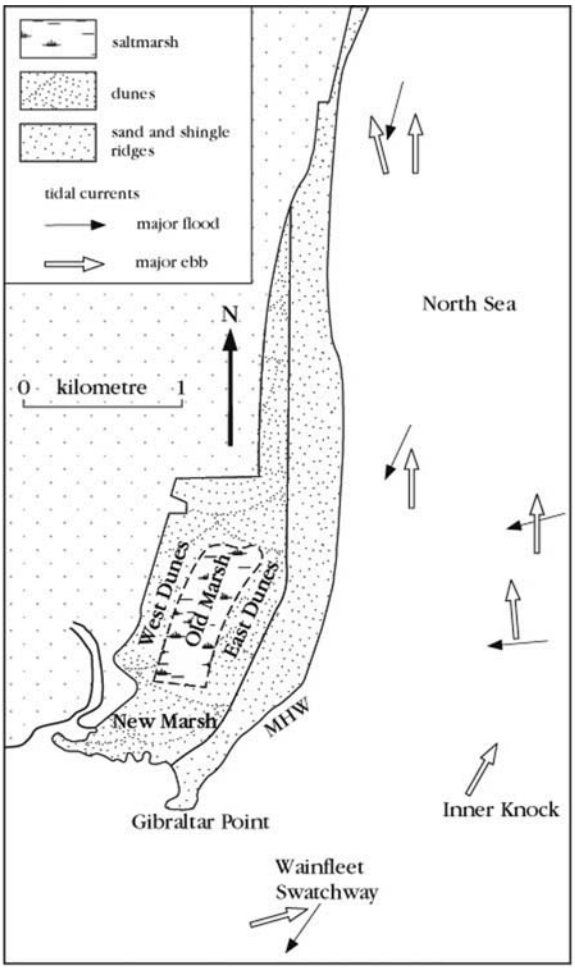

Figure 8.12: The key features of Gibraltar Point. Tidal currents based on Dugdale (1977). The West Dunes developed during the 19th century and the sandy ridge of Gibraltar Point since the 1920s.

Tidal streams have been measured in the marsh creeks and in the nearshore zone by specially devised current meters. Wave action and longshore movement have been studied by means of fluorescent tracer experiments (Fox, 1978). Beach profiles can also be related less directly to the processes operating on the foreshore. Tidal sediment movement has been studied by drifter releases in the nearshore zone and by samplers in the New Marsh creeks. Windblown sand movement has also been recorded in sand traps on the dunes. There is considerable scope for further development of these process studies.

Interpretation

Since medieval times, most of the Lincolnshire coast has retreated between 400 and 800 m, the main agent of erosion being storm waves as well as storm surges, which breach the coastal defences and flood the land-claimed marsh behind them (Owen, 1952; 1974–1975). The worst of the recent surges occurred in 1953, when flooding was very serious and caused extensive damage. Since this storm, the sea defences have been rebuilt more strongly and they mostly withstood the 1978 surge, which destroyed Skegness pier. Erosion is now confined to the area between Skegness and Mablethorpe. In the last 150 years, the Gibraltar Point area has been accreting naturally (Fraser, 1979) to produce a wide range of features (e.g. Psilovikos, 1974, 1979). The offshore banks have been studied (Dugdale, 1977; Russell, 1978), using a variety of techniques. Current-meter studies show that northerly ebb residuals are dominant seaward of the Inner Knock, whereas southerly flood residuals occur close to the shore between the Skegness Middle Bank and the shore, and along the Wainfleet Swatchway between the Inner Knock and Gibraltar Point. These paths by which sediment reaches the foreshore have been confirmed by drifter experiments. Dugdale (1977) suggests that there is a closed circulation of sand between the offshore sandbanks and the beaches. Sediment size is related to tidal current and coarse sediments are found where currents are strongest, and the finest in the most sheltered positions, such as in the lee of the flood shield near the north end of the Inner Dog's Head. The minor bed forms, which include ripples, mega-ripples, sand waves, large sand waves and a flood tidal shield, also reflect the pattern of tidal streams, mega-ripples indicating high-energy environments.

One of the qualities that makes Gibraltar Point an area of special importance is the wide range of features that develop together to form a system that demonstrates clearly the processes of accretion in a relatively sheltered environment on a low-lying macrotidal coast. Tides, waves, wind and vegetation all play an important part in the rapid evolution of the morphology of the area. Nearshore banks and channels are formed wherever strong rectilinear tidal streams have access to a supply of sand-sized sediment. The southern North Sea and the Irish Sea, with a supply of glacially derived sediment, have excellent examples of these forms (e.g. Ainsdale, Lancashire, see GCR site report). They have been extensively studied, particularly along the east coast of England, with special emphasis on East Anglia, where several different interpretations of their relationship to coastal changes have been put forward. Thus the studies made of the nearshore tidal banks off Gibraltar Point are of considerable interest and importance.

The foreshore is wide and sandy with well-developed ridges and runnels. These features are characteristic of a coast locally supplied with an excess of sand in an area where waves are usually short, and therefore, require a fairly steep equilibrium gradient. Wave action produces the ridges in order to create an equilibrium slope on a foreshore whose overall gradient is too flat. Such ridges occur, for example, on the Lancashire coast and in areas of accretion with a low overall gradient in the North Sea where the average waves have a period of about five seconds. Because the longest and most constructive waves approach Gibraltar Point from the north, the southward ridges diverge slightly from the coastline. Thus on any one profile the ridges move inland. This occurs at a rate of up to 100 m a^{1} until the ridge reaches the upper foreshore, when the growing ridge to seaward protects it from further wave action. It then becomes the foundation of a foredune. The operation of this process has been recorded in detail just south of Skegness, where, between 1955 and 1972, six ridges successively became stabilized during the period of most rapid accretion following the storm surge of 1953 (Barnes and King, 1953, 1955).

Series of profiles surveyed at several points between Gibraltar Point and Skegness (King, 1964, 1968a, 1973) show clearly the rapid accretion just south of Skegness, where the Skegness Middle Bank approaches very close to the lower foreshore. This took place mainly during the late 1950s, 1960s and early 1970s. More recently, accretion has been greater farther to the south at Gibraltar Point, and erosion has spread south from the north towards central Skegness. The height of the ridges is related to the rate of accretion, as the greater the accretion rate the lower the overall gradient of the foreshore becomes. The ridges are highest in the centre of the foreshore, and thus the sweep zone is widest here. It is narrowest at the top of the foreshore, where the banks are stabilized, and at the bottom, where drying nearshore banks prevent effective wave action at low tide. The gradual shift southwards of the zone of most accretion has been due to the slow southward migration of the Skegness Middle Bank. The accretion causes shallow nesses of accumulation, with a generally convex plan curvature to the sea, to form. The nesses gradually migrate south causing the variation of accretion at different profiles over time, as recorded in the repeated surveys. This longshore drift is responsible for the formation of the spit at Gibraltar Point.

The development of the spit has been studied by annual surveys, which provide evidence of its change in length, height, volume, and vegetation cover (Barnes and King, 1957; King, 1970). The new saltmarsh that developed in its shelter has been studied in detail (Harper, 1976, 1979; Hartnall, 1982), using stakes to measure accretion rates, as well as measuring currents, sediment concentration and details of vegetation (to assess their roles in the growth of the marsh and its creeks). The spit prolongs the upper foreshore where the coast turns abruptly into the Wash. It is a small spit of sand with a little shingle, derived from the glacial deposits and is the latest of a series of spits, each of which has been built farther to seaward than its predecessor. Armstrong's map of 1779 shows a spit prolonging the mature western dune line, which then formed the frontal system. During the 19th century this spit was preserved as the newer dunes developed east of the old system, a new spit prolonging these eastern dunes at the end of the 19th century. The end of this second spit was destroyed by the 1922 storm surge, which created the storm beach and truncated the end of the eastern dunes. The present-day spit has developed since this date.

Until about 1965, the spit continued to grow in length, height and volume, and it moved landwards by about 70 m. Since the spit became stabilized, vegetation has become established on its crest. During the 1980s this vegetation became denser, thus helping to preserve the feature despite a reduction in volume caused by the growth of a ness to the north. It will probably be starved of material as another spit develops seawards of it. This will continue the type of development recorded for former spits, and helps explain the small size of this spit compared with others on the east coast, such as Spurn Head and Orfordness. The spit at Gibraltar Point has formed by stabilization of a ridge on the upper foreshore, in a similar position to the sand dunes, which form one of the distinctive elements of this coastal system.

Sand dunes can be seen in a wide range of stages of development. The foredunes form from the uppermost beach ridges as they become stabilized by the growth of ridges to seaward. They become arcuate in form as their southern end is driven landwards once the northern end is stabilized. Once they are stable, windblown sand adds to their height, and this is trapped by vegetation. Grasses are the earliest colonizers: Lyme-grass *Elymus juncea* is followed by *Leymus arenarius* and marram *Ammophila arenaria* when the height is further increased and the frequency of tidal inundation reduced. As the dunes become more mature, sea buckthorn *Hippophae rhamnoides* becomes dominant, covering the stabilized eastern dunes. *Hippophae rhamnoides* also covers the dune slacks when they are blocked from the sea by the formation of the storm beach. The western dunes, which are about 100 years older, show a much more mature and mixed vegetation, including elder *Sambucus nigra*.

Saltmarshes of various types and in various stages of development occur at Gibraltar Point. Marsh slacks are elongated strips of marsh between the foredunes. They represent the runnels that have accreted owing to the deposition of silt in the shelter of the stabilized ridge to seaward. Vegetation again plays an important part in the accumulation of silt in the runnels. All stages of development are visible at Gibraltar Point, including the changes from initiation of a slack to the stage when only the highest tides can inundate it. Wider areas of marsh occur in the area. One lies between the main western and eastern lines of dunes. This is now mature, the inner part being a freshwater marsh, whereas the outer part between the old and the new spits is still covered by the high spring tides that flow up and spread out from the creek systems. The marsh exhibits a typical east coast mature marsh vegetation at the salting stage (see Figure 10.4). Sea purslane *Atriplex portulacoides* dominates the lower interfluves while the slightly higher creek levees are covered by sea couch *Elymus atherica*, sea lavender *Limonium vulgare*, sea aster *Aster tripolium*; other mature salting plants are present locally. The most northerly British presence of shrubby seablite *Suaeda vera* occurs in the marsh. This shingle plant indicates former shingle and sand ridges in the marsh, outlining their curved form. The marsh also provides examples of various types of pans. The drainage of the outer edge of the marsh was reversed by the building of the storm beach across its seaward end during the storm surge of 1922, which blocked one of the main creeks.

The New Marsh has developed since the 1922 storm surge when the new spit started to develop and provide the shelter necessary for deposition of fine-grained sediment. An aerial photograph taken in 1946 (the earliest evidence of new marsh development) shows mudflats devoid of vegetation apart from a narrow strip near the western end of the storm beach. Up to about 1960 the marsh was dominated by cord-grass *Spartina* spp. and creek development was also taking place (Barnes and King, 1961). By 1970, vegetation covered most of the marsh, including large stands of glasswort *Salicornia* spp., annual sea-blite *Suaeda maritima* and common saltmarsh-grass *Puccinellia maritima*, and the creek pattern was well developed. The marsh sediments include medium silt to sand, the latter being washed through the low proximal end of the spit in stormy high tide conditions, or blown from the spit by easterly winds. Since 1922, 1.4 m to 1.6 m of marsh sediments have accumulated. The mean annual rate of accretion, as measured in detail in the 1970s, is in excess of 40 mm a^{-1} in the centre of the marsh, falling to less than 20 mm a^{-1} in the upper part of the marsh. The mean rate over the marsh as a whole was 17.8 mm a^{-1}. The winter rate of accretion was found to be three times the summer rate, despite the die-back of some annual species of vegetation. The increase can probably be explained by the greater silt content of the incoming tidal waters during the winter owing to increased storminess. A strong correlation was found between data for wind speed, wave height and monthly suspended sediment. Some parts of the marsh are changing more than others, the central area showing the greatest changes and the strongest seasonality of deposition. Changes are most erratic in the lowest part of the marsh; there the River Steeping is gradually changing course, causing rapid erosion in places and equally rapid deposition elsewhere as its meanders shift. The New Marsh thus provides a dynamic environment in which saltmarsh processes and vegetation development are well displayed.

Conclusions

Gibraltar Point is one of a small number of sites around the British coast that have been the focus of more than 50 years of continuous geomorphological research. It includes intertidal sandbanks offshore, well-developed ridge-and-runnel forms on the foreshore, a spit, sand dunes and saltmarshes. The interaction between tidal and other coastal processes has been a key focus of research. One of the main reasons for its importance from the geomorphological point of view is the dynamism of the environment. Changes can be measured over short time spans. For example, seasonal variation of accretion on the New Marsh, annual movements of the beach ridges, and changes of the spit can be recorded relatively simply. The vegetation of the foredunes, marsh slacks and New Marsh also repays close study, since variations and development are rapid.

Gibraltar Point consists of many different subsystems, which include the nearshore tidal ridges, the ridge and runnel foreshore, the backshore with its arcuate foreshore dune ridges and dune slacks. The spit prolongs the upper beach ridge and shelters the New Marsh. The mature marsh (Old Marsh) is separated from New Marsh by the storm beach, a feature that illustrates the importance of the occasional extreme event in the area's development, when more change may occur in a few hours than years of normal sedimentation.

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