Chapter 8 Sand spits and tombolos — GCR site reports

Introduction

V.J. May

Sand spits and tombolos in Britain are associated with

1. areas of wide intertidal sandflats
2. estuary mouths
3. intensive erosion of cliffs that provide copious longshore sand supplies, and
4. comparatively sheltered locations.

Typically, they are low in height: even when dunes occur on them, the main structures are only a few metres in height. They are dynamic features of the British coast, for although sandy structures have been in their present sites for many centuries, they have changed in detail, undergoing erosion, breaching and accretion. Although some are still extending, they are also often marked by narrowing and breaching of their proximal (landward) ends. The term 'sand spit' is typically used for any low ridge of sand extending from the shore across an embayment, estuary or indentation in the coast and they have a number of forms (Figure 8.1), ranging from those that cross the mouths of estuaries or bays, such as at Forvie, Aberdeenshire, or to those that form barrier islands. Some sand structures, in contrast, link hard-rock features to the mainland or to islands (for example St Ninian's Tombolo, Shetland, and parts of the Isles of Scilly). Small bay-head beaches often form as ridges deflecting small streams alongshore. Although these have been described as spits, they are often the result of shore-parallel beach ridge construction (e.g. Pwll-ddu) rather than longshore transport that has extended a spit across an estuary. Some sand spits have a distal 'spatulate form that does not display individual recurve ridges. Typically, these occur where there is a base on which the sand transported to the distal end can accumulate over a wide area. This base may be salt- marsh or mud-flats. Many spits have been built upon gravel ridges, or, in Scotland, emerged beaches as their foundation, and in some cases the presence of morainic gravels provides a basis for the distal parts of these spits (for example Spurn Head, Yorkshire and Whitford Spit, Carmarthen Bay). In some cases, the spits also form the base upon which important dune systems have developed, such as in Central Sanday, Orkney or at Luskentyre, Sellebost and Gualan in the Western Isles (see GCR site reports).

(Table 8.1) The main features of sediment sources and tidal ranges of sand spit GCR sites, including coastal geomorphology GCR sites described in other chapters of the present volume that contain important sand spit structures in the assemblage of features. Many machair sites have small sandspits — see Chapter 9. (Sites described in the present chapter are in bold typeface)

Site	Main features	Other features	Present-day natural sources of sediment	Tidal range (m)
Pwll-ddu	Sand spits		Local fluvial and shallow nearshore	8.2
Ynyslas	Sand spit	Dunes	Estuarine, longshore (reduced)	4.1
East Head	Sand spit, distal dunes		Restricted alongshore: mainly from offshore banks	3.4
Spurn Head	Major spit in macro-tidal environment	Dunes	Longshore and offshore	6.4
Dawlish Warren	Sub-parallel double spit	Dunes	Intertidal banks	4.1
Gibraltar Point	Series of spits, effects of extreme events	Dunes	Longshore and offshore banks	7.0

Walney Island	Barrier islands recurved spits	Till cliffs	Cliff erosion	9.0
Winterton Ness	Linear dunes on cuspate foreland		Longshore	2.6
Morfa Harlech	Spits and recurves, ridge and runnel	Dunes	Longshore limited, intertidal estuarine banks	4.5
Morfa Dyffryn	Tombolo and dunes, sam	Dunes	Longshore limited, offshore possible but unconfirmed	4.3
St Ninian's Tombolo	Tombolo	Dunes, climbing dunes	Nearshore and some local reworking	1.1
Isles of Scilly	Tied islands, spits	Emerged beach	Local feeder cliffs and platforms	5.5
Central Sanday	Tombolos, spits, sandflats, dunes	Gravel ridges, machair, dunes	Local reworking and nearshore machair	3.0
Eoligarry	Emerged tombolo	Sand dunes and machair, bowthroughs	Local and offshore, biogenic sources from the east	4.0
Culbin	Bluckie Lock spit	Emerged gravel strand-plain, dunes, saltmarsh	Nearshore and erosional recycling	3.6
Morrich More	Innis Mhór sand spit	Emerged strandplain, dunes, saltmarsh	Fluvial, glaciogenic and offshore	4.3
Tentsmuir	Shore-parallel dune ridges, ness	Sand dunes, intertidal sands	Estuarine and longshore, significant	4.4
Luskentyre–Corran Seilebost	Sand spit	Sand dunes and machair	Nearshore, intertidal to the east	3.8
Forvie	Shore-parallel dune ridges, spit	Unvegetated and parabolic dunes	Longshore and recycled from estuary	3.1
Torrisdale Bay	Dune landforms, climbing dunes	Sandspits, intertidal sandflats, saltmarsh	Fluvial and offshore, limited	4.0
Holy Island	Barrier beaches, spits	Emerged beach, dunes	Longshore and offshore	4.1
Scolt Head Island, North Norfolk	Barrier beach, recurved spits	Dunes	Longshore and offshore	5.6
Newborough Warren	Spits, modem and relict	Dunes	Intertidal estuarine banks offshore, local reworking	4.7
Carmarthen Bay	Spits	Dunes, cliffs	Fluvial/estuarine, offshore and intertidal banks, local reworking	8.0
Braunton Burrows	Distal estuarine shore-parallel spit	Dunes	Fluvial/estuarine, offshore and intertidal banks, local reworking	7.3

According to Pethick (1984), British coastlines with a tidal range of less than 3 m are noted for their spit development. However, sand spits are not restricted to areas with low tidal ranges: spits both in sand and gravel are a common feature of the high tidal ranges of the eastern English Channel and also occur on the Scottish coast. Pethick (1984), Goudie (1990) and Goudie and Brunsden (1994) provided incomplete maps of British major spits, defining a 'major' spit as being longer than 1.5 km (Pagham Harbour being the smallest mapped). Of 34 sand spits on the British coast south of a line between the Solway Firth and Fraserburgh, (thus omitting all the machair sites with spits and the numerous small spits in sealochs and voes of the Scottish Highlands and islands) 12 lie on coasts with a tidal range less than 3 m, and 22 on coasts with a tidal range greater than 3 m (Table 8.1) and (Figure 8.2).

Where sand spits are supplied primarily by longshore sediment transport, many are affected by erosion at their proximal end. This may result from up-drift coast protection structures (e.g. groyne fields) or from reductions in the natural rate of longshore sediment supply brought about by changes in wave direction or changes in the amount and nature of the sediments in the source region. For example, along parts of the English west coast, erosion of till and head deposits (the former sources of sand) has exposed hard-rock coasts from which the sediment supply is much reduced. Reductions in sediment supply have also forced adjustments in coastal orientation with updrift erosion of many spits, as occurs at Culbin and Whiteness Head (see GCR site reports in Chapters 11 and 6). Similarly, estuarine sediment supply may be significantly reduced or increased as a result of changes in catchment management. East Head (Chichester Harbour, Sussex) contrasts strongly with many other spits in continuing to grow in volume even when longshore transport to it has been substantially reduced.

Many sand spits are associated with extensive intertidal areas of sand banks and submerged bars at the mouths of estuaries. It is evident from the studies of some sand spits that they depend to a significant extent upon the trans port of sediment from these areas. Sand nesses (e.g. Winterton Ness), although less common than the gravel forms, are associated with offshore shoals, but the directions and quantities of sand moving between them are uncertain.

The problem of breaching of the proximal end of spits, and the potential demise of the feature, besets the management of many other sites (e.g. Spurn Head, Hurst Castle Spit, Dawlish Warren). Although it has been argued by de Boer (1964) in relation to Spurn Head that this can be shown to be part of a natural cycle of events, at other spits it is attributable to the reduction of longshore transport resulting from cliff or beach protection works. Kidson (1963), however, suggested that many spits were dominated by erosion and were well into a final stage of development leading to their extinction. The geomorphological interest of spits thus lies partly in their potential for self-destruction.

One recurrent feature of many sand structures is the development of separate and distinct ridges, seen for example at a small scale at Pwll-ddu, in parallel double spits at Dawlish and in multiple recurved ridges at Morfa Harlech. Similarly, many of the features are marked by recurrent breaching of the spit. Whereas de Boer's cyclic breaching hypothesis for Spurn Head has now been re-evaluated (see below), other sand spits such as East Head show periodic breaching of the main features often at their proximal ends. Many of the spits have not grown simply as a result of longshore transport extending a spit gradually across an embayment. Most show a characteristic of sudden rapid extension possibly resulting from rapid shoreward movement of sand ridges, followed by localized reworking and a period of comparative quiescence. Breaching or the construction of another ridge often then takes place. However, there are documented instances of the inlet becoming permanently sealed by longshore extension, as occurred at Strathbeg, Aberdeenshire in the 18th century, see GCR site report in Chapter 7.

Evolution of sand spits and structures

Although the GCR sites described in the present chapter show — in their alignment facing the dominant waves — a similar tendency to the beaches described by Lewis (1932, 1938), sandspits are much more dependent upon the foundations provided by lag deposits from erosion of rocky coasts and in particular glacial deposits. For example, Spurn Head, Morfa Dyffryn and Whitford Burrows depend in part upon the presence of remnant Devensian moraines. Similarly, the development of transgressive gravel ridges and the erosion of coastal platforms on low-lying coasts have provided the foundations for both transgressive sand ridges and for the extension of sandy beaches across estuaries. Roy *et al.* (1994) distinguish between the flux of sediment on wave-dominated sandy coasts and the movements of barrier sand masses during sea-level changes (which include phases of transgression, stillstand and regression). Many of the sand structures described here may result from a combination of these processes. Some features, which have been regarded in the past as the result of longshore transport, appear in fact to result from the transgression of barriers. These became restricted in further onshore movement by the pre-existing topography and have been re-shaped by subsequent wave conditions. The debate in Robinson's 1955 paper about the formation of double spits at the mouths of estuaries in southern England focused on two separate processes: longshore spit development and subsequent breaching as opposed to 'frontal accretion' (as Robinson called it, which can be regarded as a form of barrier development). Sites such as East Head and Spurn Head, although of different scale, have developed as the result both of longshore sediment transport and transgression, and such origins need to be considered for other similar structures.

Carter (1988) considered the concept of the coastal cell as a framework for the long-term development of spits. In his view, spits, like all beaches, depend upon the balance between the flux of wave energy (total shoreline wave energy per unit wave crest per unit time *ECn*) towards the shore (shore-normal P_N) and along the shore (shore-parallel P_L). The angle made with the shore by the breaking wave (α_b) affects the magnitude of P_L whose spatial distribution alongshore can be mapped. Where waves break parallel to the shore, $\alpha_b = 0$ and sediment is simply transported up and down the beach. However, on a spit, the breaking angle increases rapidly around the recurve, although at the same time wave height decreases due to wave refraction. As a result, P_L remains constant except at the farthest distal curve. This implies that the spit will only survive as a long-term feature as long as there is a sufficient longshore supply of sand to maintain the longshore component of sediment transport. Few British sand spits fit this model exactly. For many, the longshore supply of sediment is interrupted either by periods of weaker, or longer-term reduction in, longshore supply and transport or by direct interruptions as a result of the construction of structures such as groynes. For example, in parts Scotland, sediment reduction and sea-level rise has led to smaller coastal cells than before, and has forced internal re-organisation of sediments, manifested by updraft erosion and downdrift accretion of spits at Culbin and Spey (Hansom, 2001). Furthermore, where spits enclose large open bodies of water, waves also affect the behaviour of the spit on its landward side and can bring about significant changes in the overall development of the spit (e.g. Spurn Head). This model also largely ignores the role of the intertidal and offshore routes by which sand is transported often with different values of P_L. For example, both Dawlish Warren and Morfa Harlech (see GCR site reports in this chapter) display different patterns of wave breaking at low water from those affecting the upper beach and the main spit form. The effects of very long-period swell, high-energy events, surges and short periods of waves from opposite directions from the prevailing waves may each provide explanations for some of the sand structures around the British coast. Once developed, many of these features are very persistent forms. Although some features have developed in their present locations during the last 1000 years, many others are built upon a foundation that is considerably older: the spits at Culbin have ancestors that span most of mid—late Holocene times.

The conservation value of sand spits and associated structures

The conservation value of sand spits and structures arises from:

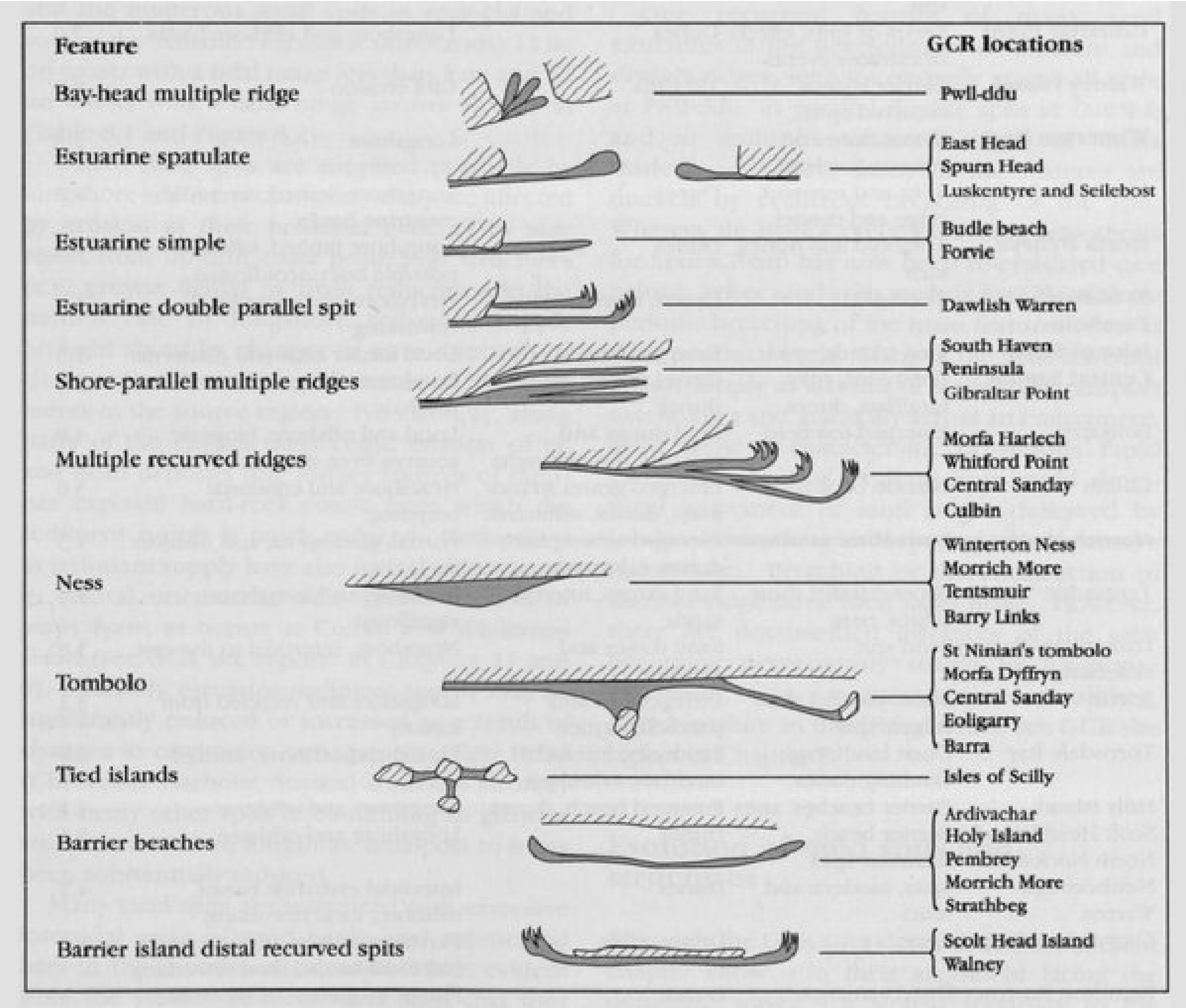
1. their historical role as areas of accumulation of sediment, so providing the basis for pioneer plant species to colonize the area,
2. their links with intertidal and offshore banks and bars as part of the sediment transport system,
3. their association with dunes and ecology,
4. their role in narrowing the entrances to estuaries and providing protection for the development of extensive mud flats and saltmarshes in the resulting shelter,
5. their place in coastal education and research. Three of the longest-running continuous coastal university research programmes are based on major sandy structures at Spurn Head (University of Hull), Gibraltar Point (University of Nottingham) and Scolt Head Island (University of Cambridge) since the 1920s, and
6. the fact that many remain largely undisturbed by artificial structures and development.

Sand spits are also very important:

1. in providing sheltering structures at the mouths of navigable estuaries,
2. in their role as natural coast protection structures providing low-cost protection to low-lying coastal land.

Despite their dynamism, many of these structures are of considerable age, with documentary and archaeological evidence for their existence and growth reaching back over many centuries. Some of the structures have built up during the historical period and so it is possible to assess the ways in which these features have resulted from environmental changes within their coastal and river settings. Some of the sand structures are important assemblages of many geomorphological forms that demonstrate the different ways in which sandy coasts adjust to differences in sediment availability and changes in climate and oceanic conditions. Their conservation value derives from their present-day features and in demonstrating the ways in which the coastal environment adjusts to change can be observed and their persistence understood.

In this chapter the site reports are ordered so that the more simple forms precede the more-complex ones: Pwll-ddu, Ynyslas and Spurn Head are simple spits with spatulate form, lacking recurves; Dawlish Warren, Gibraltar Point and Walney Island are double/subparallel spits with some recurves; Winterton Ness has a cuspate form; Morfa Harlech is a large cuspate form with extensive recurves, Morfa Dyffryn a simpler cuspate-like spit, more accurately described as a tombolo; St Ninan's Isle displays classic tombolo forms, and the Isles of Scilly tied islands; and Central Sanday has an assemblage of features.



(Figure 8.1) Sand spits and their associated structures, indicating some key representative GCR sites.

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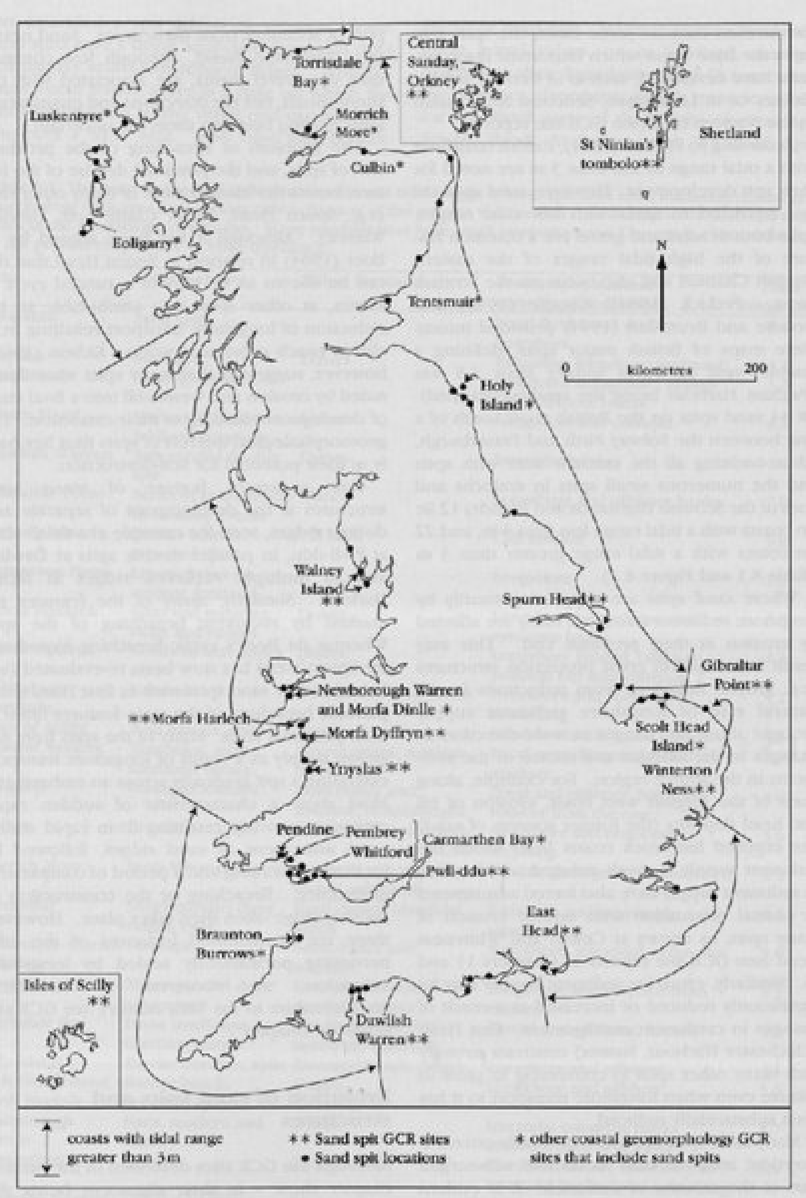

(Figure 8.2) The location of sand spits in Great Britain, also indicating other coastal geomorphology GCR sites that contain sand spits in the assemblage. (Modified after Pethick, 1984).