Dawlish Warren, Devon

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Introduction

The coastal spit at Dawlish Warren is a classic landform that extends from the western side of the Exe estuary (see (Figure 8.2) for general location) and diverts the main channel towards Exmouth. This complex sand spit at the mouth of the estuary is dominated by two parallel ridges, the more seaward of which has a broad distal end. Extensive sandbanks to seaward affect the low-tide and intertidal wave-energy distribution, but the beach form is largely the product of a combination of wave patterns at high tide levels and the discharge of the estuary, so that currents may control the sediment distribution more than waves (Figure 8.10). The site is now partly modified by gabions buried beneath the shoreline dunes and by a wall at its proximal end. Erosion has become acute here in recent years following protection of the cliffs to the south-west that had formerly provided at least part of the former sediment supply.

Description

The spit (Figure 8.10) extends for about 2 km north-eastwards across the Exe estuary from cliffs originally cut into Permian breccia and conglomerate, but now entirely formed by an artificial shoreline of boulders, timber structures and a concrete sea-wall. This area is mostly excluded from the GCR site. The spit is about 500 m wide throughout its length, but is made up of several distinct units. The landward side of the spit supports an area of saltmarsh that has developed in its shelter. To seaward, the Inner Warren, is a low hummocky area of former sand hillocks resting upon day, probably of estuarine origin, and 0.6 m to 0.8 m-thick shingle layers (Kidson, 1964b). The Outer Warren comprises a line of semi-fixed dunes of varying width behind a discontinuous line of sand hills between 25 m and 50 m in width and rising to a maximum of about 6 m in height. The distal part of this ridge widens into a triangular area that preserves several former shoreline ridges (Figure 8.11). There is a wide intertidal beach, which is connected at low tide to a large sandbank, the Pole Sand. Within the estuary, another large sandbank, Bull Hill Sands, is separated from the distal end of the spit by the channel of the Exe. Both sandbanks include substantial quantities of gravel at depths of –1.3 m to –1.6 m OD. The sand of the spit itself is as much as 20 m in thickness and rests upon Devensian gravels (Durrance, 1969), which in turn rest upon and fill deep channels cut into Triassic breccia. The bedrock slopes from about 0 m OD at the inner end of the spit to about –20 m OD beneath the distal end. A series of NW–SE-trending palaeochannels that have been cut by fluvial processes to below–40 m OD meander across it. Kidson (1964b) reported that the bedrock of Checkstone Reel which underlies part of the Pole Sand, is occasionally exposed.

The spit appears to have existed in its present-day position on the western side of the Exe estuary since at least the 16th century. Martin (1893) was unable to confirm local reports that at one time it extended across the estuary from the eastern shore at Exmouth. Throughout its documented history (i.e. since 1869) Dawlish Warren has been undergoing erosion. The Outer Warren has been breached frequently and the shape of Warren Point changed considerably. When high spring tides are accompanied by south-easterly gales driving high onshore waves, the lowest part of the ridge is overtopped and breached. The breach is subsequently rebuilt as waves from the south and south-west move sand along the spit and extend it. At the same time the face of the beach and dunes is eroded and so the spit retreats. Sand is also blown from the dune ridge towards the distal end. Sand eroded from Warren Point may be transported into the estuary or may travel towards the Pole Sands. Kidson (1964b) pointed out that erosional phases at Warren Point were not associated with any increase in the volume of sediment in the Pole Sands. The interplay of different wave directions has produced a highly dynamic form.

Interpretation

The nature and behaviour of the sand spit at the mouth of the Exe has been a focus of geomorphological attention since the 1860s (Peacock, 1869; Martin, 1872, 1876, 1893; Kidson, 1950, 1964a,b; Mottershead, 1986). Steers (1946a) commented that an unusual feature was the formation of two spits — an inner and an outer which was then unexplained. Pethick (1984) described it as a detached beach and Bird (1984) identified it as an example of a spit that has been artificially armoured. Most attention has been given, however, to the erosion and expected demise of the spit. Kidson (1964b, p. 178) described it as the 'outstanding example of a depositional feature which has passed through this period of stability and is now well advanced in the fmal stage leading to ultimate extinction'. Peacock (1869) had already forecast its ultimate extinction.

Some authors in discussing the dominance of erosion (Martin, 1893; Clayden, 1906; Steers, 1946a) have suggested that the construction of the railway towards Teignmouth in 1849 reduced cliff erosion and cut off the supply of sediment to the spit. Kidson (1950) has shown, however, that the rate of retreat of the face of the spit over the 100 years before and after the construction of the railway was comparable, and concluded that its impact was negligible. Comparison of the shorelines mapped by Kidson (1950) suggests that the spit has migrated landwards as a unit rather than suffering greater erosion at its proximal end, as might be expected if the reduction in longshore transport were the key factor in its retreat. Interestingly, however, Kidson suggested that much of the sand forming the spit was derived from erosion of the cliffs to the west. Rapid erosion of the cliffs at the end of the Holocene rise in sea level would probably have supplied most of the sand for the spit. Even if erosion was already active on the spit by the mid-19th century, the reduction of sand supply from the west cannot be ruled out as one factor in the continuing decline of the spit.

The Warren is sandy, unlike other beaches in the region, which are shingle (Mottershead, 1986). Mottershead noted that the River Exe has a drainage basin an order of magnitude larger than any other rivers flowing to this coastline. As a result it would have been able to deliver a much larger volume of sediment. As sea level rose during the Holocene Epoch these sediments could have been driven landwards to form the spit. This was, therefore, a 'once-only' mechanism according to Mottershead, who saw this as a realistic hypothesis in the absence of any published analysis of the mineralogy of the sands forming the Warren. This would suggest that sediment is no longer being supplied to the spit.

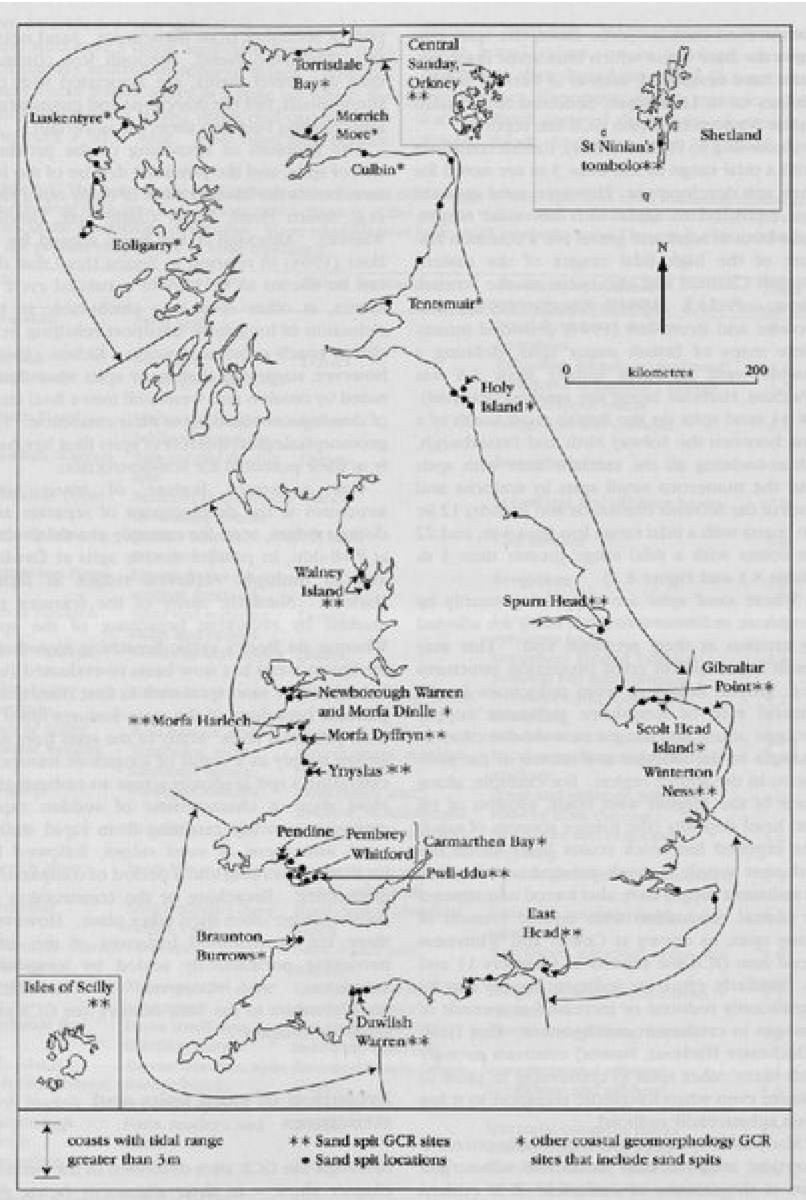
A second issue, which was noted by Steers (1946a), concerns the double (parallel) nature of the spit. Mottershead (1986) suggested that Kidson (1963) believed that the Inner Warren was probably an accumulation of windblown sand derived from the Outer Warren. Kidson, however, saw the area around Warren Point as the receiving area for sand blown from the Outer Warren. He suggested that the Inner Warren was a normal spit that built across the estuary with both wave-borne and windblown sand built into dunes on a shingle base. Neither author examined the reasons for the development of two separate spits.

The cartographic and documentary evidence points to the Warren as being developed from two spits. The Inner Warren could have developed as a spit across the estuary, but set well back from its mouth. During a period of reduced sediment supply, it might have migrated into the estuary. The intercalation of clay and sand layers suggest that this spit, like most others, migrated on to the marshland behind it, but that more rapid marshland sedimentation transgressed the landward sandy beaches before the present-day pattern developed. With the older spit pushed back into the estuary and sand supply to it cut off because of the presence of Langston Rock, it would have been possible for a new spit or beach ridge to develop. The effect upon wave energy distributions of the underlying gravel and bedrock could produce sedimentation and longshore transport, which would initiate a new spit in much the same original position as the earlier one. The new one would then migrate up the estuary, overlapping the older feature.

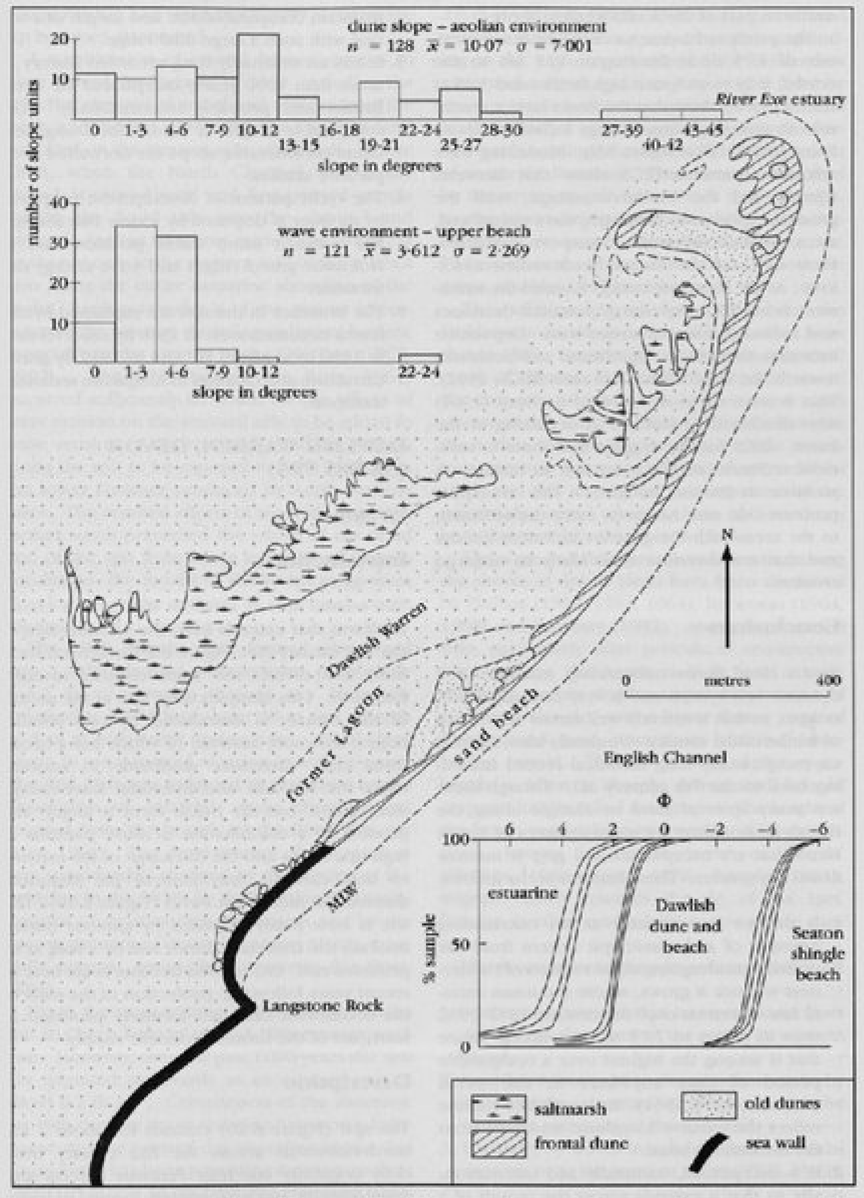
The spit has now been armoured to reduce the chances of broaching and to ensure its survival as part of the sea defences in the lower Exe. As Kidson pointed out this may well be a futile exercise, as the long-term pattern here has been an erosional one. There is a need to understand much better the sedimentary pathways around the spit especially in the intertidal area.

Conclusions

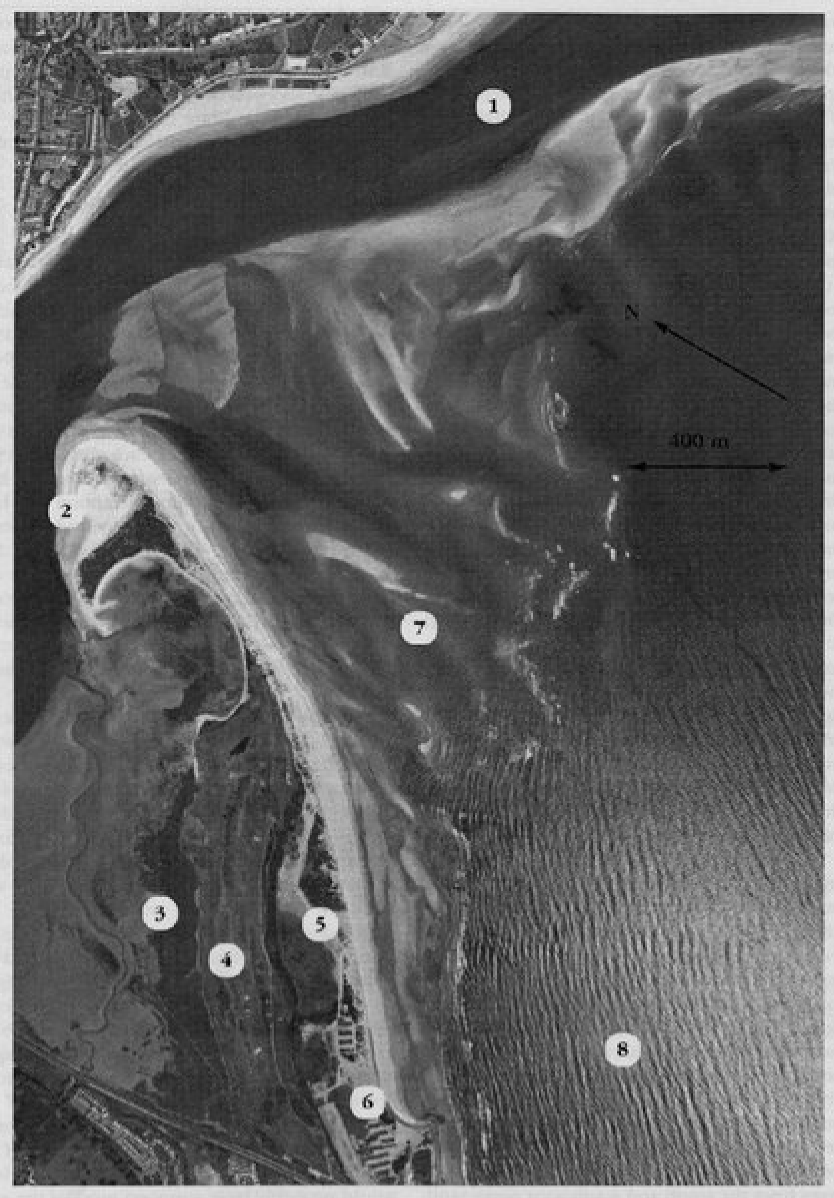
Dawlish Warren is an important site for four reasons. First, it is a good example of a spit in the later stages of development. In this, it complements such features as Hurst Castle Spit, Hampshire, and Orfordness, Suffolk. If sea-level rise becomes more rapid, it can be expected that many more coastal features will show the changes that have occurred at Dawlish Warren. The efficacy of coastal engineering works in similar situations needs to be carefully evaluated and so this site offers a natural test-bed for measures to adjust to the rise of sea level over the next century. Second, it is unusual in having a double parallel form, for there are few such features in Britain. The nearest analogous site is at South Haven Peninsula, Dorset, and Gibraltar Point, Lincolnshire, has some similarities. Neither, however, has developed across a major estuary. Third, its predominantly sandy sediments make it unusual on the south coast of England where most beaches are of shingle and sandy spits are rare. Finally, the intertidal banks both within the estuary and to seaward form an integral part of this beach system, with the result that, unusually for the coastline of southern England, fluvial as well as marine sediments are a sediment source.



(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 8.10) Key geomorphological features of Dawlish Warren, showing differences in slope on dunes and the upper beach, and differences in sediment sizes. n = number of observations of slope angle; R = mean slope angle; a = standard deviation. (I) = –log, (grain diameter in mm); the grain-size profile for estuarine material and for Seaton, Devon, are shown for comparison.



(Figure 8.11) Aerial photograph of Dawlish Warren with the main geomorphological features numbered. 1 = Exe estuary, main channel; 2 = active recurved distal end (Warren Point); 3 = saltmarsh; 4 = inner spit (largely modified); 5 = outer spit; 6 = proximal end coastal protection works; 7 = intertidal sandbanks; 8 = prevailing and dominant wave direction (from the south-east). (Photo: courtesy Cambridge University Collection of Aerial Photographs, Crown Copyright, Great Scotland Yard.)