WHITENESS HEAD

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OS Grid Reference: NH802587–NH842568

Introduction

Whiteness Head on the south shore of the Moray Firth, north-east Scotland (for general location see Figure 6.2), is a classic example of an actively prograding spit of *c.* 3.5 km long. It is composed entirely of gravel ridges whose ends recurve southwards into an area of saltmarsh and intertidal sandflat (Figure 6.29). The gravel ridges are capped by small amounts of windblown sand. Westward sediment transport along this shoreline has resulted in the progressive westerly growth of Whiteness Head (Stapleton and Pethick, 1996; Ramsay and Brampton, 2000c), the historical evolution of which has been well documented (Ogilvie, 1923; Steers, 1973; Smith, 1974; Halliwell, 1975; Stapleton and Pethick, 1996; Bentley, 1995). From a short gravel bar in the 1880s, the end of the spit at Whiteness Head has migrated in a westerly direction at rates of between 10 and 30 m a^{-1} over the last 150 years. Such downdrift growth of the distal end of the spit is currently fuelled by updrift erosion of its proximal end (Ritchie, 1983; Bentley, 1995). The Whiteness Head SSSI comprises one area on the eastern side of the Ardersier Platform Construction Yard (an oil rig construction facility), and another area on the west side of the yard. The GCR site lies entirely within the eastern part of the SSSI.

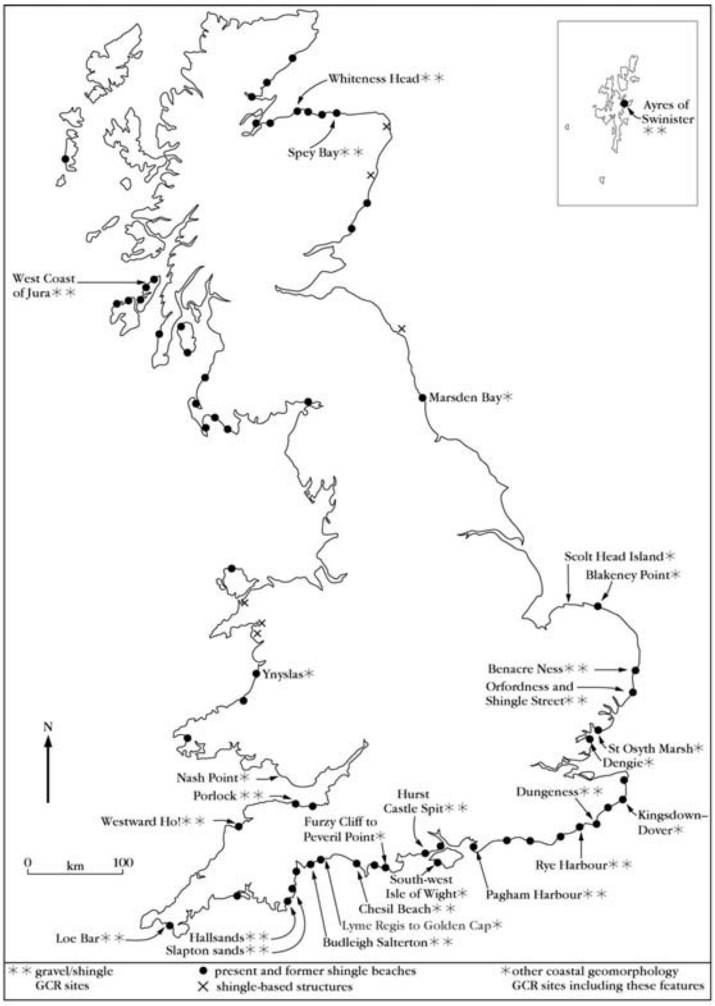

Figure 6.2: Coastal shingle and gravel structures around Britain, showing the location of the sites selected for the GCR specifically for gravel/shingle coast features, and some of the other larger gravel structures.

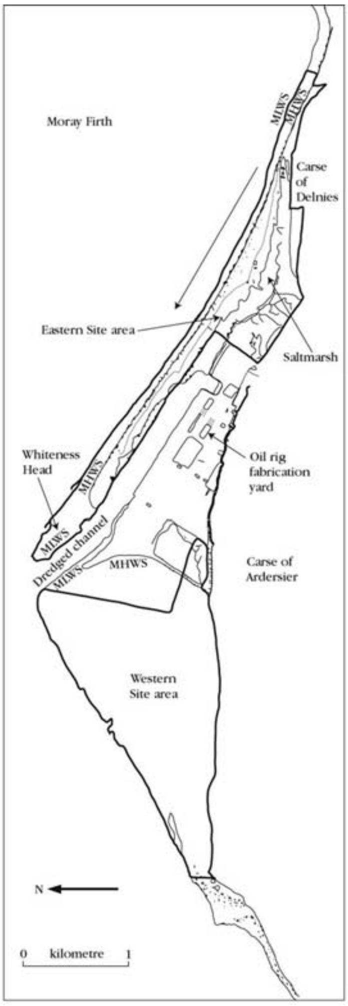

Figure 6.29: Sketch map of the Whiteness Head area. The GCR site lies entirely within the eastern site area; the arrow indicates direction of net longshore sediment movement.

Description

The gravel spit at Whiteness Head protrudes out from the southern shore of the inner Moray Firth, in a north-westerly direction. At its broadest the 3.5 km-long gravel spit is *c*. 200 m wide, although it narrows to less than 15 m close to the updrift end, and encloses *c*. 1 km^2 of saltmarsh and intertidal sandflat on its southern side (Stapleton and Pethick, 1996). To the west, extensive mudflats extend to the glacial till headland of Ardersier, whereas to landward, the spit and saltmarsh are backed by a complex of emerged Holocene sand and gravel deposits backed by a prominent, 10–12 m-high, emerged cliff (Ritchie *et al*., 1978).

Whiteness Head spit consists of at least seven recurved gravel-spit complexes, each one partially truncated at its proximal end by the succeeding one (Ritchie *et al*., 1978) (Figure 6.30). They lie at altitudes of between 3 m and 5 m OD and are separated by saltmarsh and dry gravel slacks. In general, the highest ridges form the active beach and lie on the seaward (northern) margin of the spit. The upper beach face consists of a gravel storm-ridge with a steep seaward slope of over 10°, increasing to 18° in the centre of the spit (Bentley, 1995). The lower beach face is characterized by a low-gradient sand slope with intertidal bars. The beach face is also punctuated by well-developed, but ephemeral, suites of rhythmic cuspate forms. The offshore hydrography indicates a gentle offshore gradient passing into deep water beyond a narrow sloping shelf with no evidence of a submarine bar system in the nearshore zone.

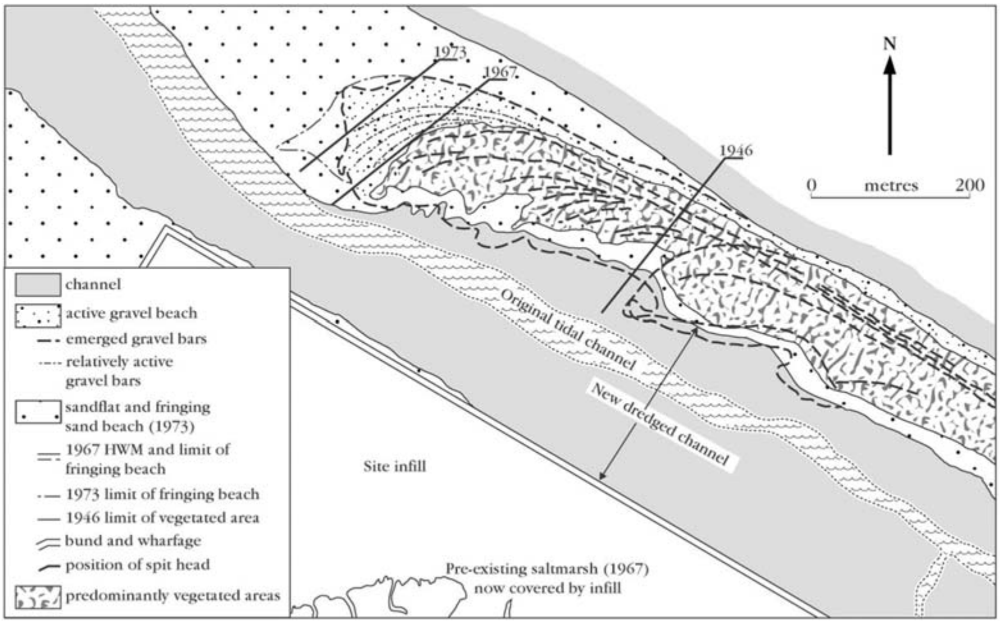

Figure 6.30: Map of historical changes in the Whiteness Head Spit between 1946 and 1973. (After Smith, 1974.)

Extending along the entire length of the spit parallel to the outer coast, a prominent gravel ridge marks the limit of storm-wave action. This laterally mobile storm ridge is almost 2 m higher than the older recurved ridges and is over-topped by waves during storm-wave activity (Bentley, 1995). It declines in height eastwards towards the proximal end of the spit where a low plateau of gravel extends landwards into the saltmarsh as a series of lobate washover fans. This has imparted a crenulate inner edge to the spit at its narrowest point. Known locally as ‘the Gut', the gravel storm ridge forms the only barrier preventing waves from entering the saltmarsh behind, although wave over-topping and erosion is common during storm activity (Bentley, 1995). This eastern part of the spit is also characterized by erosion of the older gravel ridges, which trend at an angle to the present-day coast. This results in truncation of the seaward ends of ridges and slacks to form an undulating gravel cliff whose height is usually less than 0.7 m (Ritchie *et al.*, 1978; Bentley, 1995). Accretion and growth occurs at the distal (western) end of the spit where the storm ridges of the outer beach form a series of landward-trending gravel recurves, which are rapidly colonized by pioneer plants. Ongoing westward extension is now curtailed by maintenance of the tidal channel at the distal end by dredging.

Although the spit is composed almost entirely of gravel, the distal (west) and inland portions are locally overlain by a thin cover of blown sand, seldom exceeding 2 m in thickness (Bentley, 1995). The dune forms in this location are subdued as a result of episodic deflation and wave overtopping and the underlying gravel base is exposed in several places. In the place of a true foredune system there is a rather irregular sand mantle of amorphous mounds capped by marram grass *Ammophila arenaria*, although small areas of narrow linear dunes capped by blue lyme-grass *Leymus arenaria* have formed atop the gravel ridges, particularly at their distal ends. In the east, a dense cover of *Ulex–Calluna* (gorse–heather) communities occurs but this changes westwards through *Ulex– Ammophila* communities to *Ammophila* and eventually to a dominance of *Leymus* on the most recent embryonic dunes at the extremity of the spit. For a fuller description of the vegetation of Whiteness Head see Currie (1974).

The inner (southern) beach of the spit is characterized along its length by small bays that have formed between the recurved ends of the relict gravel ridges marking former positions of the distal end of the spit (Figure 6.30). Along this inner edge a wide intertidal sand-flat is exposed at low tide although this merges landwards into gravels that underlie saltmarsh. The saltmarsh is drained by a system of creeks and there is a marked absence of saltpans. Dominant species on this marsh include samphire *Salicornia*, common saltmarsh-grass *Puccinellia maritima*, sea aster *Aster tripolium*, sea plantain *Plantago maritima*, greater sea-spurrey *Spergularia media*, red fescue *Festuca rubra*, sea-milkwort *Glaux maritima*, thrift *Armeria maritima* and cord-grass *Spartina anglica* (Stapleton and Pethick, 1996).

Interpretation

The Moray Firth is landlocked except in the sector 000° –090° and so north-easterly swell and wind waves dominate. Although smaller wind waves generated in other sectors within the firth can be significant, the dominant direction of wave energy is from the north to north-east sector and incident waves meet the shoreline obliquely. This has strongly influenced the alignment of coastal features, the net westward drift of sediment being manifest in the orientation of spits along the middle and inner Firth including at Speymouth, Lossiemouth, Findhorn Bay, Buckie Loch, The Bar at Culbin and Whiteness Head. Erosion of the coast is thus at its most severe under north and north-easterly storms. Tides in the Moray Firth lie in the range 3.5 m at springs, but they generate relatively weak currents because, rather than being directed into the firth, the tidal wave crosses its entrance (BGS, 1996). However, the co-incidence of a north-easterly gale and high spring tides can elevate water levels considerably along the coast, producing locally significant erosion along the southern Moray Firth.

The sea-level history of the Moray Firth is relatively well known and newly deglaciated areas were being flooded by the sea at *c*. 13 000 years BP (Firth, 1989; see Figure 6.28, Inverness curve). However, rapid isostatic recovery during this period outstripped the rate of sea-level rise, producing a fall in sea level, which was already low by the onset of the Loch Lomond Stadial. The onset of the Holocene transgression is dated at 9610 ± 130 years BP from the inner Moray Firth (Haggart, 1986, 1987), and at 8800 years BP in the Beauly Firth near Inverness (Figure 6.28). The culmination of this rise at *c*. 6400 years BP was marked in the Beauly and inner Moray Firths by the formation of the Main Postglacial Shoreline (MPS) and a series of emerged gravel ridges at up to *c*. 9 m OD at Spey Bay (Comber *et al*., 1993). Since the peak of the Holocene Transgression, sea level has displayed a falling trend to the present-day level, and is marked by a series of emerged shoreline features around the inner Moray Firth at successively lower altitudes (Firth and Haggart, 1989).

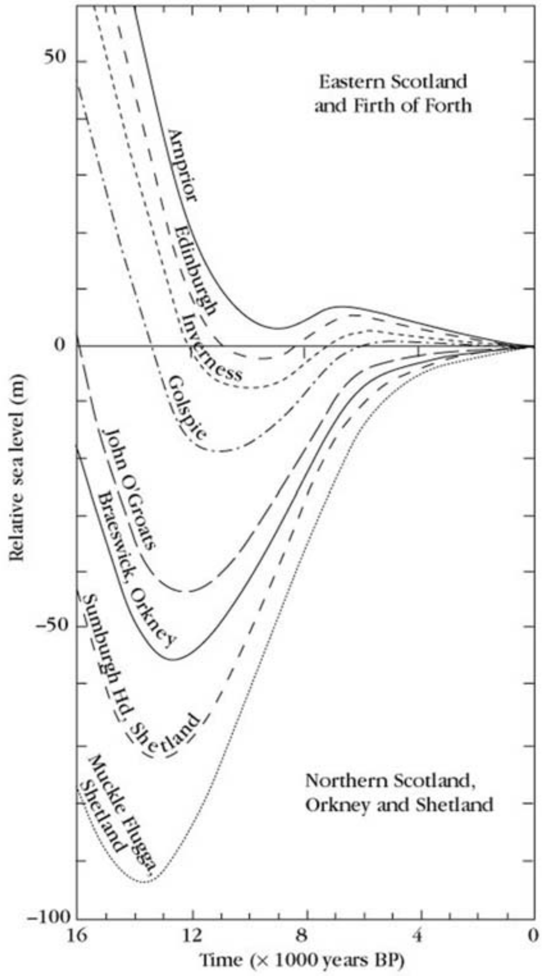

Figure 6.28: Graphs of modelled relative sea level against time over the last 16 000 years, along a south– north transect from Shetland to the Firth of Forth. (After Lambeck, 1993; Hansom, 2001.)

The prograding gravel spit of Whiteness Head is of outstanding geomorphological significance, and Whiteness Head, together with Spey Bay (see GCR site report below) and Culbin (see GCR site report, Chapter 11), form an important suite of GCR sites on the southern shore of the Moray Firth. Wave-induced westerly longshore drift predominates along this coastline (Ramsay and Brampton, 2000c) and is reflected in the coastal landforms of all three GCR sites with westerly deflected spits at Speymouth, Findhorn Bay, Buckie Loch, The Bar at Culbin and Whiteness Head. Although extensive coastal protection works at Nairn, 6 km east of Whiteness Head, has undoubtedly reduced the natural supply of longshore sediment to Whiteness Head, it has been suggested that the spit represents the early stages in the development of a 'flying barrier' similar to The Bar at Culbin (Ritchie *et al.*, 1978; Ritchie, 1983; Bentley, 1995).

The historical evolution of Whiteness Head spit is relatively well documented (Figure 6.31). The spit has been developing since before 1853 (Ogilvie, 1923), although no information is available concerning the time of its initiation. There are reports that in 1823 no gravel was present at Whiteness Head, and although Steers (1973) considered this statement to be highly unlikely, his reasons are unclear. There is great variation in the published figures of the rate of westerly growth at Whiteness Head, which probably results from either differences in the methods used to calculate changes, or in the actual growth of the spit, which may have been pulsed, with some years experiencing more rapid growth than others (Bentley, 1995). For example, Ogilvie (1923) states that the spit had grown by 1070 m in 70 years, a rate of 15.2 m a^{-1}, while Steers (1973) reported the spit to have extended 823 m between 1868 and 1937, a rate of 11.9 m a^{-1}. In the 10 years between 1955–1965 the spit is reported to have extended 304 m, an annual rate of 30.4 m a^{-1}, whereas in the following 10 years (1965–1975) this rate of westerly growth had slowed to 18.2 m a^{-1} (Halliwell, 1975). Based on a comparison of the earliest (1880) and most recent (1977) Ordnance Survey maps, the overall westerly extension of the spit is 1.48 km, giving an average annual growth rate of 15.2 m a^{-1} (Stapleton and Pethick, 1996). This long-term average growth rate corresponds exactly with the rate quoted by Ogilvie (1923). The range of westerly growth rates of Whiteness Head are remarkably similar to those measured at The Bar, Culbin, which has been shown to extend westwards at a mean rate of 14.6 m a^{-1} between 1976 and 1989 (Comber, 1993). Both spit features can be seen to be predominantly moving to the west rather than landwards, although proximal erosion is a feature of both.

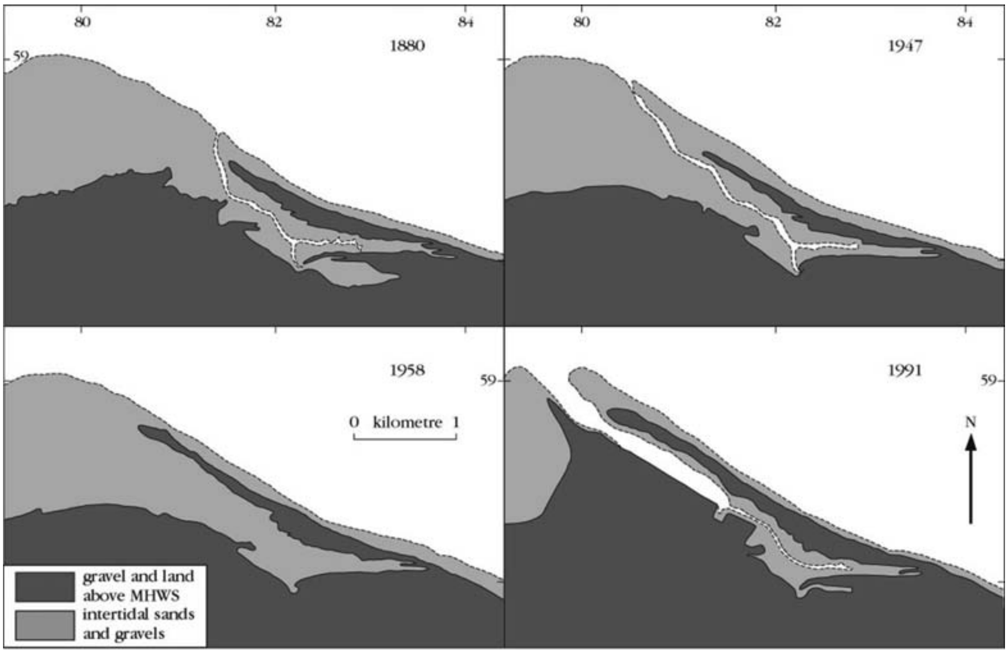

Figure 6.31: Historical evolution of the Whiteness Head Spit between 1880 and 1991. In 111 years the spit has lengthened considerably and the creek morphology has changed. Note the pronounced change between 1958 and 1991 when the McDermott construction yard was built and a prominent channel was dredged on the south side of the spit. (After Stapleton and Pethick, 1996.)

As occurs elsewhere in the Moray Firth, westerly longshore drift of sediment has been the driving force behind the creation and continued migration of the gravel spit at Whiteness Head, its westward growth resulting from updrift erosion fuelling gravel accretion at its distal (western) end where newly deposited recurved gravel barriers develop. Most of the sediments responsible for the construction of the features of this coast were originally derived from rivers and offshore sources accumulated in the Moray Firth basin during Lateglacial and Holocene times, and plentiful before about 6500 years BP (Hansom, 1999). However, in common with coasts elsewhere (Carter, 1988, 1992), the amount of sediment has since diminished and on the Moray Firth coastline there has been a progressive reduction in both gravel and sand supplies to the coast. In a situation of sediment starvation coastal development proceeds via internal re-organization of existing sediments and so current spit extension is probably entirely fuelled by the truncation of older ridges at the proximal end and recycling of sediment downdrift (Hansom, 2001). Continued growth of the spit is thus at the expense of updrift erosion.

The impact of this process on coastal alignment can be identified in the erosional truncation of the older gravel ridges, which trend at an angle to the present-day ridge orientation. There has also been a north-eastwards movement of the whole system as the spit builds out seawards and an increase in intertidal width at the distal end of the spit (Stapleton and Pethick, 1996). As a result of updrift erosion and downdrift accretion, the spit has 'rotated' clockwise over time from an east–west alignment to a south-east–north-west alignment (Bentley, 1995). Where sediment supply is restricted, this rotation is consistent with the concept of a wave-driven progression in the evolution of beach alignments from an original state of drift-alignment towards an equilibrium state of swash-alignment (Davies, 1972). As there is no reason to assume that the gravel shortage is a temporary phenomenon, it has been suggested that a continuation of the present mode of spit development (i.e. proximal erosion fuelling distal accretion) will eventually result in the severance of the spit near its hinge-point and the creation of a detached barrier similar to that at Culbin (Smith, 1974; Ritchie *et al.*, 1978; Ritchie, 1983; Bentley, 1995).

A significant proportion of the previous extent of the saltmarsh was reclaimed during the building of the Ardersier Platform Construction Yard in 1973. The yard lies to the landwards of the GCR site and occupies a 120 ha site of former saltmarsh and emerged mudflat (carse) (Smith, 1974). Land-claim was achieved by suction-dredging of sand from the intertidal zone landwards of the spit and deposition into settling ponds behind sand bunds, which were infilled to a level of *c.* 4 m OD (Smith, 1974). A dredged channel is now maintained to a depth of up to 12 m and the yard edge adjacent to the channel is protected with a steel wall (Smith, 1974) (Figure 6.29). Erosion is currently a problem at the eastern end of the wall and parts of the claimed land are suffering erosion (Bentley, 1995). Although the geomorphological interest of the intertidal flats and saltmarsh behind Whiteness Head has been diminished by the dredging and land-claim operations, the outer beach remains a classic example of a rapidly prograding gravel spit complex. It is an important site for the study of the processes of active spit development and migration, in a context of sea-level fall, relative sediment starvation and active longshore drifting. As a result, the site is of importance to the understanding of the long-term evolution of dynamic gravel spits.

Conclusions

Whiteness Head on the south shore of the Moray Firth, north-east Scotland, is a classic example of an active, rapidly prograding gravel spit. The *c.* 3.5 km-long dynamic spit complex, which has been migrating westwards at rates of 10–30 m a^{-1} over the last 150 years is of outstanding national geomorphological importance. The relatively well-documented historical evolution of Whiteness Head adds to the scientific interest and provides a key to understanding the long-term evolution of gravel features in areas of active longshore drift. Today, in a period of relative sediment starvation and sea-level fall, updrift erosion of the spit is currently fuelling downdrift accretion and driving the continued westerly migration of the spit complex. It is possible that a continuation of the present-day processes will result in the severance of the spit from the mainland creating a detached barrier similar to that at Culbin (see GCR site report in Chapter 11).

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