DUNNET BAY

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OS Grid Reference: ND215710–ND201682

Introduction

The wide sand beach of Dunnet Bay, Caithness, (see Figure7.1 for general location) is backed by a massive, sharp-crested, coastal dune ridge with a gently sloping links plain on its landward side. The general morphology and scale of this extensive beach–dune–links system is unique in Britain. The coastal dune ridge is dissected by numerous spectacular, wide, deep blowthroughs at various stages of development. As blowthrough stability ranges from stable to extremely active, Dunnet Bay provides a key site for studies of blowthrough initiation, growth and natural or artificial stabilization. The dune and links also support important species-rich vegetation and invertebrate communities. Despite the enormous research potential at Dunnet Bay it has failed to attract any detailed geomorphological research, although two mainly descriptive accounts of the site exist (Ritchie and Mather, 1970a;Bentley, 1996c), and Hansom and Rennie (2003) have recently quantified coastal changes.

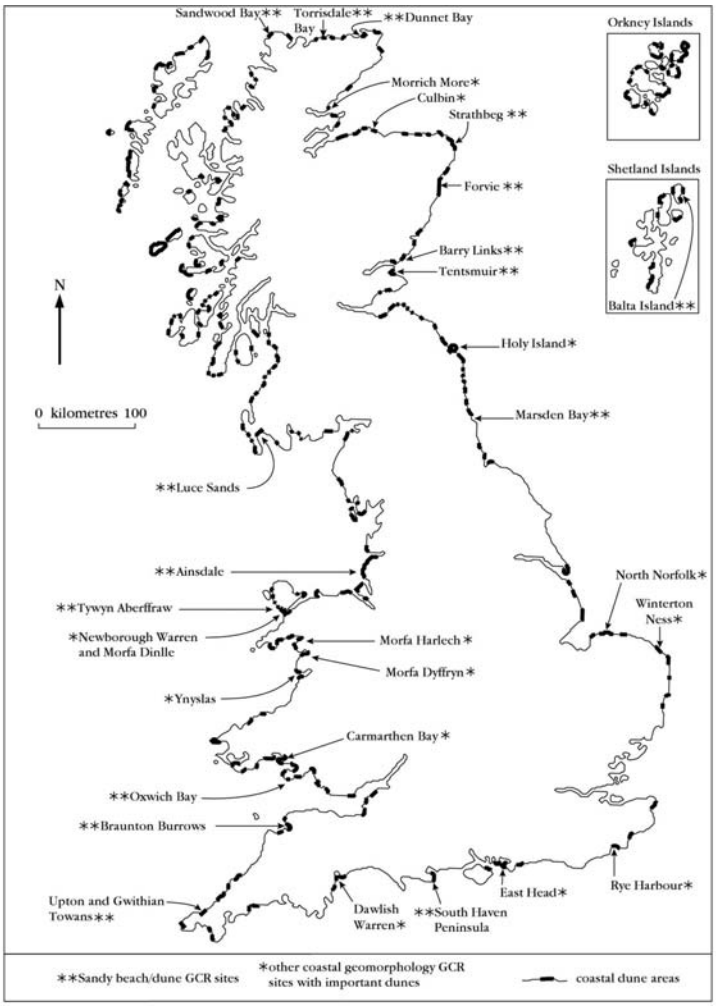

Figure 7.1: Great Britain sandy beaches and coastal dunes, also indicating the location of GCR machair-dune sites (see chapter 9) and other coastal geomorphology GCR sites that contain dunes in the assemblage.

Description

The GCR site of Dunnet Bay lies at the head of a 4 km-wide, 6 km-long embayment on the

north coast of Caithness. Inland, the Dunnet Bay structural depression extends south-eastwards across the country to Sinclair's Bay on the east coast of Caithness. As a result of the enclosed nature of Dunnet Bay, between the high sandstone cliffs of Dunnet Head to the north and the low flagstone platform to the south, it can been described as a sediment trap (Ritchie and Mather, 1970a). In addition, the deep penetration of the embayment means that incoming waves are almost completely refracted, arriving at the beach with their crests parallel to the arcuate beach.

The beach at Dunnet Bay is one of the largest in northern Scotland (Ritchie and Mather, 1970a), extending for over 4 km in a broad symmetrical curve (Figure7.28). The intertidal zone is wide, with an average width of 180 m, and has a uniformly low gradient of 1–2°. Offshore the seaward gradient is also gentle, at about 1:124 (Ritchie and Mather, 1970a). The beach is composed predominately of relatively fine-grained sand (D_{50} = 0.31 mm) of which 20% is $CaCO_3$ and is flanked by low rocky shore platforms at either end. Immediately adjacent to the rock platforms the upper beach is composed of coarse gravel that then grades to sand.

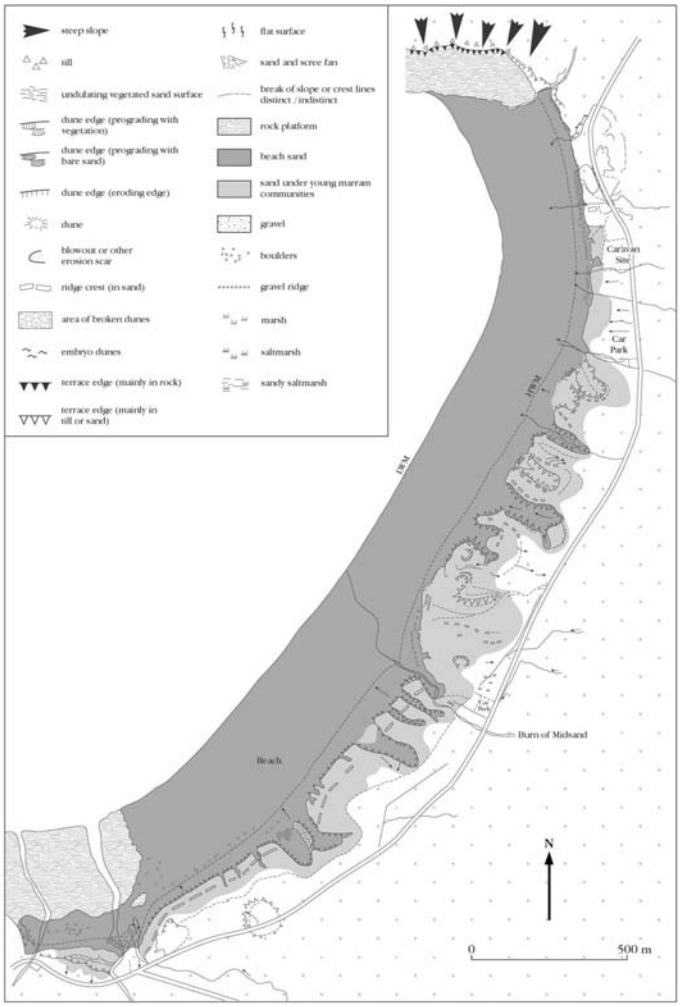

Figure 7.28: The coastal landforms of Dunnet Bay and dunes showing a coastal dune edge that is both undercut by frontal erosion and punctuated in several places by large, linear, blowthrough corridors. (Based on Ritchie and Mather, 1970a and Hansom and Rennie, 2003.)

The wide beach is backed by a massive, steep (>30°) and high dune ridge (Figure7.29). The backslope of the dune is less steep (12–16°) and has a slightly concave-up profile. The dune ridge reaches a maximum height (up to *c.* 20 m OD) and width (*c.* 350 m) towards the middle of the bay. Both the height and width decline towards the southern and northern ends. Frontal erosion of the dune ridge is evident along almost its entire length (Figure7.29). In October 1996 the dune face was partially revegetated, and low embryo dunes had formed in places at the back of the beach, a result of calm summer conditions. Frontal dune erosion is

predominantly due to wave attack at the dune base particularly during winter storms. Erosion is not a new phenomenon at Dunnet Bay and in 1970 the greater part of the dune front was over-steepened and in places undercut during storms (Ritchie and Mather, 1970a).

Figure 7.29: The wide expanse of Dunnet Bay looking west over the indented exit of the Burn of Midsand. Much of the coastal edge comprises mature dunes whose edge is now steep and undercut and whose surfaces now support re-invigorated marram growth. (Photo: J.D. Hansom.)

The dune ridge is dissected by nine streams flowing from the links plain to the sea. The largest stream, the Burn of Midsand, flows into the centre of the bay through a prominent break in the dune ridge, while the others have cut narrow V-shaped valleys through the dunes (Bentley, 1996c). Low embryo dunes have developed at the mouth of the Burn of Midsand as a result of the increased local sediment supply.

Morphological diversity of the main dune ridge is created not only by streams but also by numerous spectacular blowthroughs that dissect the dunes. The blowthroughs form several flat-floored, steep-sided erosion ‘corridors' through the dune ridge and several saucer-shaped depressions on the windward slope of the wide dune ridge. The blowthroughs, which are often 10–12 m deep, up to 30–40 m wide and often devoid of vegetation, are some of the largest in Scotland (Bentley, 1996c). At least seven large blowthroughs at various stages of activity dissect the dune ridge. Several of the blowthroughs are compound, where two or more have joined laterally leaving only residual pinnacles of the former dune ridge between the areas of bare sand. A large blowthrough at the northern end of the bay forms a narrow corridor through the dunes. As this blowthrough is visible from the main road it is utilized as an access track to the beach for both pedestrians and vehicular traffic (i.e. quad bikes, motorbikes etc.), exacerbating the natural erosion processes. The blowthrough is extremely active, with evidence of wind being channelled through the corridor, scouring the sand and re-depositing it over the ends of the blowthrough as lobes of unconsolidated material. Attempts have been made to stabilize this blowthrough, along with several others, using sand fences and marram planting. This has not been entirely successful; in October 1996 the fences were full of sand and thus were no longer effectively trapping new sediment. The steep slopes flanking the active blowthrough corridors are generally unvegetated and extremely unstable, with evidence of loose sand slumping downslope. Gravel is exposed at the base of several of the larger blowthroughs. Between the large blowthroughs a number of smaller V-shaped blowthroughs penetrate the dune ridge.

Two blowthroughs to the north of the central stream can be described as relict blowthroughs, as although they are stable and fully vegetated they have retained their original form. The

stabilization of these blowthroughs was undertaken by the Forestry Commission who used brushwood and the planting of coniferous trees (Ritchie and Mather, 1970a). Although this stabilization has been successful in that the landforms have effectively been frozen *in situ* at a previous stage of high instability, the remaining presence of over-steep slopes and topographical depressions that still channel onshore winds at high velocities may lead to instability at a later date.

Landwards of the wide coastal dune ridge a gently undulating links surface extends for up to 5 km inland. The main Castleton to Dunnet road, which lies landwards of the dune ridge, separates the dune environment from the more stable links area to the east. The long erosional blowthrough corridors and their associated re-depositional sandhills have been known to reach the main road and during winter storms sand is often blown across the road to the links area (Ritchie and Mather, 1970a). The GCR site includes a small representative area of the links to the east of the road in the northern part of the site. The links is formed entirely of blown sand that has been deposited over peat, till and bedrock (Bentley, 1996c). The beach–dune–links system of Dunnet Bay is unusual as the relatively steep dune backslope grades directly into the low-lying area of dune pasture, with an absence of secondary or older dune forms farther inland.

Interpretation

Dunnet Bay forms part of the GCR network of coastal sites on account of its unique dune morphology. The single, massive, sharp-crested coastal dune ridge is dissected by numerous spectacular large blowthroughs at various stages of activity and is backed landwards by an extensive dune pasture and links topography. The scale and range of activity in the various forms of dune blowthroughs and the relatively frequent occurrence of direct wave attack at the base of the dune ridge add geomorphological diversity and enhance the scientific interest. There remains much scope for research at Dunnet Bay particularly concerning the initiation, growth and stabilization of both wind- and wave-induced erosional forms.

Steers (1973) describes Dunnet Bay as ‘a feature of primary importance in the coast of Scotland' on account of its enclosed nature between the high sandstone cliffs of Dunnet Head to the north and the low flagstone platform to the south. Since it is so enclosed it acts as an effective sediment trap: the only escape for sand from the bay is landwards (Steers, 1973). It is thus not surprising that a wide, high dune system and extensive links plain has accumulated landwards of the enclosed bay (Ritchie and Mather, 1970a; Steers, 1973). It has been suggested that the gentle offshore gradient (1: 124) of the sand-covered seabed implies there is a continuing reserve of sediment in Dunnet Bay (Ritchie and Mather, 1970a). However, the presence of the large active blowthroughs and frontal erosion of much of the dune face suggests that there may now be a diminution in the offshore sediment supply.

The large blowthroughs at Dunnet Bay are naturally induced erosional forms, although human activity may have exacerbated the natural process by utilizing blowthrough corridors as access tracks to the beach. Ritchie and Mather (1970a) found no positive relationship between blowthrough location and drainage conditions, offshore sediment supply or local wind patterns and conclude that, in the absence of any known trigger mechanism, the blowthroughs have a random stochastic distribution and the dune barrier as a whole is migrating landwards. Frontal erosion together with blowthrough advance appears to be moving the total volume of the dune landwards and will continue until a new stable equilibrium position is reached (Ritchie and Mather, 1970a). This erosion may be due to an increase in wave and wind energy from the north-west or a decrease in the offshore sediment supply (Ritchie and Mather, 1970a). As with the majority of coastal dune systems in Scotland, the dominant process at Dunnet Bay appears to be one of erosion and coastal retreat, although recent artificial stabilization methods have affected the natural evolution of this system. Stabilization of the blowthroughs by planting has been relatively successful: two of the larger blowthroughs are no longer active. The use of sand fencing in several of the larger active blowthroughs, although not entirely effective and in need of maintenance, has limited landward sand transfer. Hansom and Rennie (2003) have recently quantified the rate of retreat of the coastal edge at Dunnet Bay: between 1968 and 1998, 3.6×10^5 m^2 was lost at rates of 20 m a^{-1} mainly in the centre and north of the beach.

The relatively steep dune backslope of the main dune ridge and the absence of secondary

ridges or extensive dune forms inland has been attributed to the frequency of strong winds from the south-east channelled by the structural depression between Sinclair's Bay and Dunnet Bay (Ritchie and Mather, 1970a). The to-and-fro nature of winds through this structural corridor may account for the vigour and rate of development of the blowthrough erosion corridors, which once initiated may be attacked by winds from both directions. Strong onshore storm winds from the north-west appear to be more dominant. Further research on the initiation, growth and development of these blowthroughs is required.

Gravel is exposed at the base of several blowthroughs. It has been suggested that the dune system at Dunnet Bay may rest on a gravel basement of emerged ridges and bars (Ritchie and Mather, 1970a; Steers, 1973) as is the case in many Scottish coastal dune systems (e.g. Culbin, Luce Sands and Strathbeg, see GCR site reports). This remains to be fully investigated and as no detailed height measurements are available it is unknown if these gravel forms are related to the present or to a former higher sea level. More research is warranted.

Conclusions

The unique general morphology of Dunnet Bay, which consists of a single, massive, sharp-crested dune ridge leading inland to a gently-sloping extensive links plain, is of immense geomorphological importance. The 4 km-wide arcuate sand beach is backed by a massive, steep (>30°) sharp-crested dune ridge reaching a maximum height of*c*. 20 m OD and width of *c*. 350 m. The low links plain extends up to 5 km landwards of the dune ridge. The morphology of this massive ridge is extremely diverse. It is cut by several small streams draining into the bay and, perhaps more significantly, at least seven large blowthroughs dissect the ridge. The blowthroughs, which are often 10–12 m deep and up to 30–40 m wide, are some of the largest in Scotland (Bentley, 1996c) and are at various stages of activity, ranging from stable to extremely active. The effects of artificial stabilization of the landforms is evident – at least two large blowthroughs are now essentially relict landforms stabilized by dune planting, while others have been partially stabilized by the use of sand fencing. The scale, dynamism, range of activity and diversity of the blowthroughs in this massive coastal dune ridge is of great geomorphological interest.

Reference list

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