Barry Links, Angus

[NO 550 320]

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Introduction

The Barry Links dune system has developed on an extensive broad triangular foreland (*c.* 11 km^2) on the northern side of the Firth of Tay, eastern Scotland (Figure 7.42). Although Barry Links contains representative examples of many beach, dune and links landforms, it is the exceptional series of well-developed parabolic dunes that is of outstanding geomorphological significance. Parabolic dunes are relatively rare in the Scottish coastal dune environment and are extensively developed in only three areas: Barry Links, Sands of Forvie, and Morrich More. The parabolic dunes of Barry Links are unique in that they have a pronounced V-shaped form with a mean length-to-width ratio of 3.3, compared to the more U-shaped forms of the dunes of Forvie and Morrich More (see GCR site reports), with ratios of 1.2 and 2.0 respectively (Ritchie, in MacTaggart, 1997b). The Barry Links parabolic dune systems have spectacular, elongated, hairpin shapes that are unique in Britain. The geomorphological features of Barry Links complement those of the Tentsmuir dune system to the south of the estuary, which is also of outstanding scientific merit (see GCR site report).

Description

The extensive sand-covered triangular foreland of Barry Links juts out on the northern side of the Firth of Tay, on the east coast of Scotland (Figure 7.43) and (Figure 7.44). Two 4.5 km-long sand beaches converge at Buddon Ness at the southern tip of the foreland with the extensive intertidal sandbanks of Gaa Sands, submerged during most of the tidal cycle, lying to the east of Buddon Ness (Figure 7.43). Both the east-facing and estuarine (south-facing) beaches are composed of medium-grade, non-calcareous sand (D_{50} = 0.24 mm) with occasional patches of gravel. The foreshore of the east-facing beach is *c.* 300 m wide, and flat with several intertidal shore-parallel bars. The extensive northern coast has a history of severe erosion, the dune face recorded to have retreated up to 10 m in one year (Wright, 1981). Early attempts in 1978 to combat erosion using gabions were rapidly overridden and the later 'solution' of 1992–1993 was to place rock armour on the beach and dune face along a *c.* 3.5 km length of coast (Hansom, 1999). Although aesthetically unattractive the rock armour appears to be serving its purpose of preventing further erosion along the protected stretch of coast and by 1994 there were no signs of slumping of the rock surface (ASH Consulting Group, 1994). However increased scouring at the toe of the armour combined with the loss of sand supply to the backshore from the now inactive dune face may have resulted in lowering of the backshore (ASH Consulting Group, 1994).

At the southern end of the rip-rap, an erosional bight has resulted in 50 m of recession landward of the rip-rap alignment and erosion extends to within 100 m of the Ness itself (Hansom and Rennie, 2003).

To the north of the point at Buddon Ness there are areas of local coastal accretion (Wright, 1981) where pioneer vegetation is colonizing the blown sand on the backshore. At Buddon Ness itself, where erosion appears to dominate, the beach is markedly steeper (7–8°) and narrower. Historically, the coastline around Buddon Ness has undergone considerable change (Wright, 1981), which is not surprising on account of its sensitive location at the point where the south-facing estuarine coastline changes to an open North Sea orientation. Local evidence shows considerable fluctuations in the position of the coastline. For example, by the early 19th century the site of the original Buddon Ness lighthouse, which was located on the southern extremity of the point during the early 16th century, was 6 m under water and 2 km to the south-east of the current one (Wright, 1981). West of Buddon Ness the beach is narrower (200 m) and lacks some of the morphological variety of the North Sea coast. The backshore is steeply sloping and fronts a foredune that has both actively accreting and eroding sections.

A series of long, narrow, well-vegetated coast-parallel dune ridges back the estuarine (south-facing) beach. The coastal dunes are 5–11 m high at Buddon Ness and decrease in height westwards, lowering to 1–2 m near the Buddon Burn.

The topography of this coastal dune system is complex. Towards the western end of the shoreline for a distance of *c.* 2 km there are three clearly defined sub-parallel dune ridges. Farther east the dune ridges are characterized by old blowthroughs and associated re-depositional sandhills. Close to the point of Buddon Ness this mature dune complex is fronted by a relatively narrow line of actively accreting dunes (Figure 7.43). The single coastal dune ridge along the east-facing North Sea coast has a more varied morphology. Severe wave erosion has caused relatively rapid retreat along most of this length of coastline, although recent protection works along the northern 3.5 km stretch of coastline have effectively stopped activity in this part of the eroding dune face (see above). The vegetated coastal dune ridge is discontinuous with signs of intermittent marine breaching. A complex, high relief dune morphology has developed where the parabolic dune arcs of the interior coalesce with the coastal dune ridge. The relative proximity of several of the inland parabolic dunes to the eastern coastal edge (Figure 7.43) and (Figure 7.44) poses an interesting question concerning the relative importance of coastal retreat and the eastwards migration of the parabolic arcs in producing the truncated high dune cliffs characteristic of this coastline.

Inland from the coastal dunes is an extensive area of low undulating vegetated links (generally under 6 m OD) covering most of the triangular foreland of Barry Links. A well-developed system of parabolic dunes (Figure 7.43) and (Figure 7.44) has developed on this undulating links topography. The parabolic dunes of Barry Links are unique in Britain with a well-developed and pronounced V-shape. These dunes are long and narrow with a fairly regular outline in plan view and the extent to which secondary blowthrough development has occurred is minimal. The pattern of dune forms on Barry Links displays an unusual degree of regularity. Two distinctive morphological attributes contribute to this relatively ordered appearance. Firstly, the measured length-to-width ratios are closely and evenly distributed about the mean value of 3.3 for the dune system and, secondly, the dune orientations as represented by the directions of their long axes are remarkably uniform (Figure 7.44). The 243° orientation of the Barry parabolics suggest that they have migrated in the past from the south-west to north-east, towards the eastern coastline.

The Barry parabolic dunes are now almost completely vegetated and stabilized, with the exception of the large dune that is utilized by the Ministry of Defence (MOD) as a firing range. In the northern part of the foreland the parabolic dunes stand as discrete units. Towards the south, in the vicinity of Buddon Ness, some adjacent dunes overlap although this does not appear to disrupt the general parabolic shape. Some breaks in the orderly dune pattern occur at the southern and eastern margins of the foreland, where some of the parabolic dunes have intersected the present-day coastline. The convergence of the parabolic dunes with the coastal dune ridges has resulted in the production of a high relief and complex dune topography. Isolated SW–NE-trending elongated dune ridges suggest coastal erosion has truncated a former, more extensive, system of parabolic dunes.

Interpretation

The evolution of the large foreland of Barry Links remains speculative. Its general triangular shape, comparable to accumulation features in southern England such as Dungeness, Kent (see GCR site report in Chapter 6), suggests that the area has developed as a result of extensive deposition of beach materials in the past. There appears to be little doubt that, as with much of the North Sea coast of Scotland, large parts of the foreland consist of emerged beaches. Steers (1973) posed the question of the stability of this distinctive triangular foreland. Analysis of old maps of the area covering the last 200 years show change only at the margins, suggesting that the main body of the feature is based on a more stable foundation, possibly an ancient beach or rock platform (Steers, 1973), although there is no surface indication of underlying rock. Borehole evidence (Figure 7.45) suggests that beneath the dunes lies a series of emerged shorelines cut into a thick sequence of marine sands (Buddon Sand) which themselves overlie marine clay (Errol Beds) (Paterson, 1981). The physiographical evolution of Barry Links clearly requires further investigation, particularly in the context of changing relative sea levels.

The parabolic dune system of Barry Links is one of the finest and well-developed in Britain, but there has been surprisingly little research carried out on these spectacular forms. Early work by Landsberg (1956) shows that wind regime is a major factor in the orientation of the Barry dunes (Figure 7.46). Each wind direction in proportion to its sand-moving power was plotted and the resultant vector (shown by the arrow on (Figure 7.46)) completes the wind direction polygon and indicates the direction of the dominant wind effect. This resultant vector conforms almost exactly

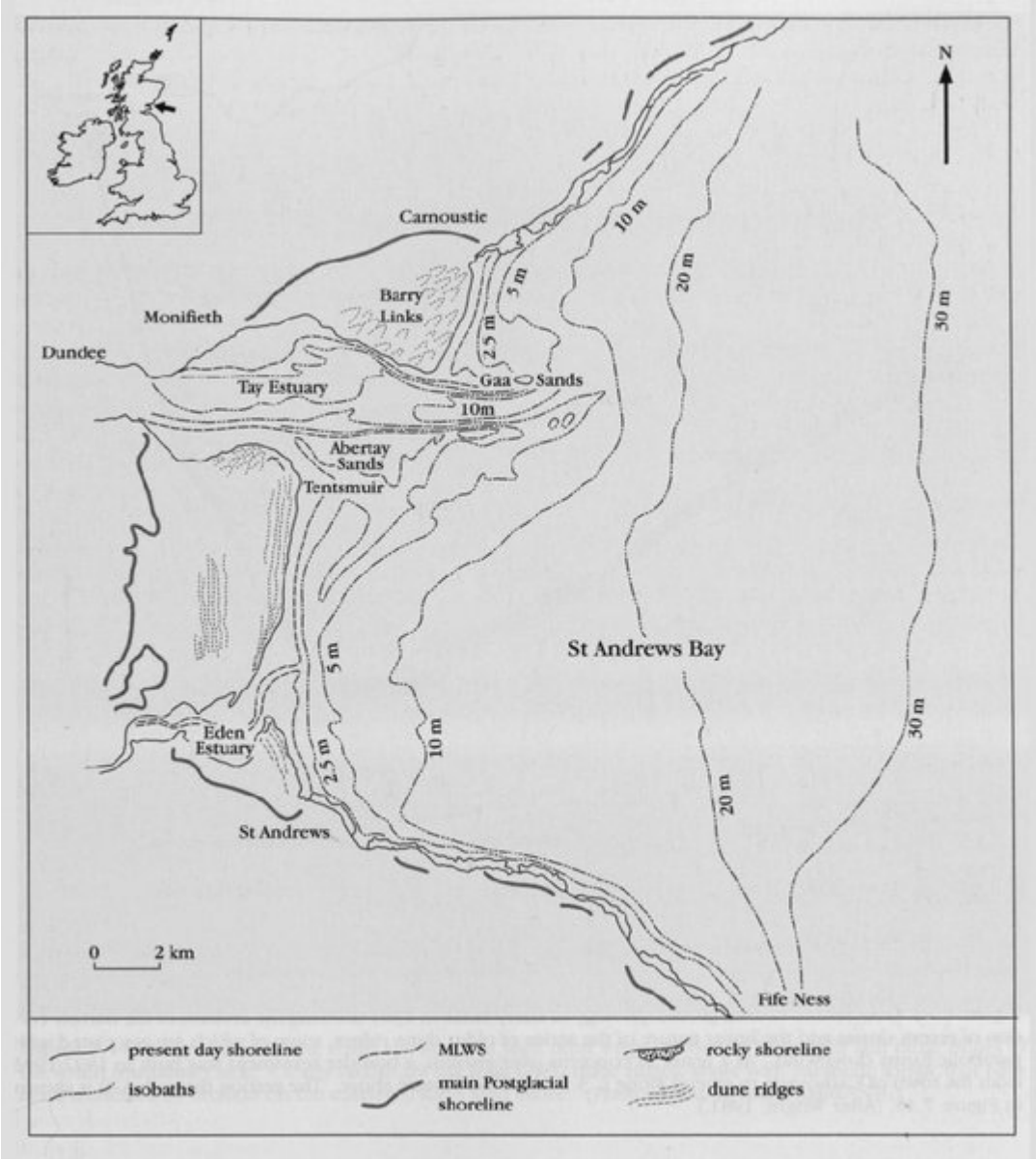
with the mean dune orientation of the Barry dunes (Landsberg, 1956). The open exposure of the Barry Links foreland and the lack of topographical interference with formative winds from the south-west may explain the regular form, orientation and pattern of the Barry Links parabolic dunes (see (Figure 7.44)). The undulating links surface is remarkably even; the parabolic dunes that have developed on this sandy plain represent the primary relief features in the area so, in the Scottish context, the wind regime is unusually free from topographic effects. In addition, the Barry parabolic dunes lack the complications of subsurface control, a common feature of many coastal dune systems (e.g. Machir Bay). This may also help explain the orderly form of the Barry parabolic dunes. Map and field evidence shows an apparent migration of the dune forms towards the eastern coastline. However the present stability of the dunes suggests that this, certainly in the recent past, may be more a result of rapid marine erosion in the east, rather than the recent downwind migration of the dunes themselves (compare (Figure 7.43), (Figure 7.44) and (Figure 7.46)).

Potential patterns of longshore sediment transport on the coasts north and south of the Tay estuary have been calculated using wave refraction modeling (Sarrikostis and McManus, 1987). The model predicts a south-westerly drift down the exposed North Sea coast of Barry Links to Buddon Ness, where deposition occurs. Field evidence appears to support this model; the southward transport of material from Carnoustie to Gaa Sands has been demonstrated by released gabion fillings on the beach face (Sarrikostis and McManus, 1987). Tidal currents also transport sediment towards the Ness from the North Sea coast on the ebb as well as the flood (Figure 7.47). The extensive coastal protection works along the northern part of this coast will clearly affect the natural balance of the coastal system. Potential sediment supply from the previously eroding dunes to the downdrift beaches (i.e. Buddon Ness) has effectively stopped through protection works and this may have long-term implications for the entire system (Hansom and Rennie, 2003).

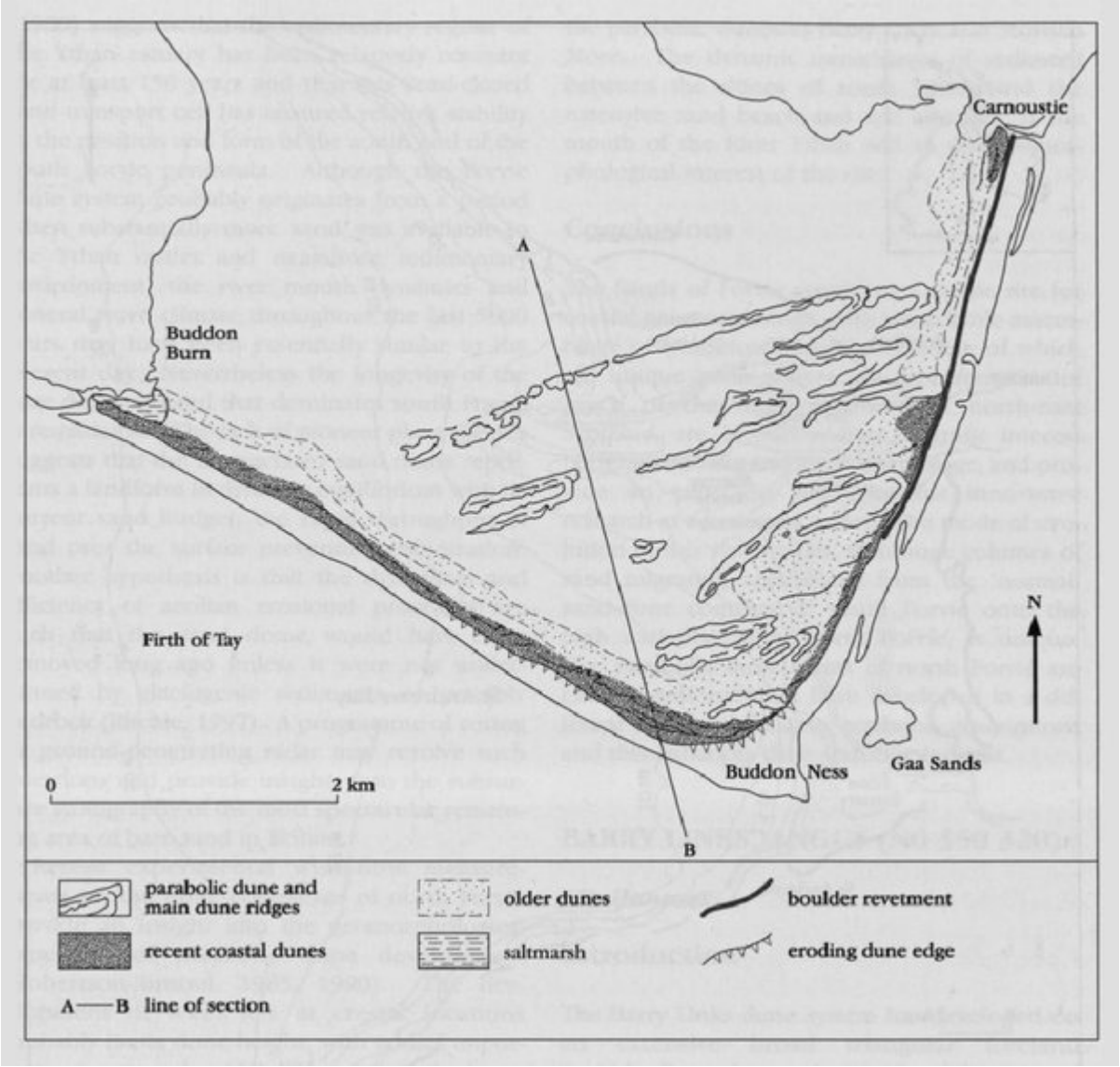
Barry Links is owned by the MOD with restricted public access. As a result, the majority of Barry Links, with notable exceptions near the firing ranges on the east coast, is relatively undisturbed and the existing land-use has produced a unique conservational environment. The site has been selected for the GCR on account of the well-preserved parabolic dune system. The pronounced V-shaped parabolic dunes are unique in Britain and demonstrate a dose relationship between wind regime and dune orientation (Landsberg, 1956). The site also provides representative examples of beach, dune and links landforms and offers a valuable complement to the study of Tentsmuir on the south of the Tay estuary, which is also of outstanding geomorphological interest (see GCR site report, below).

Conclusions

The extensive sand-covered foreland of Barry Links contains an exceptional series of well-developed and preserved parabolic dunes which are of outstanding geomorpholog-ical significance. The dune orientations show a dose relationship with local wind regime (Landsberg, 1956) and the pronounced V-shaped form of the Barry parabolic dunes are unique in Britain. The parabolic dunes, which have a mean length-to-width ratio of 3.3:1, have spectacular, elongated, hairpin shapes with an exceptional regular and orderly pattern. These unique characteristics may reflect the open exposure of the foreland, the lack of topographic interference with formative winds and the lack of subsurface control. In addition, Barry Links provides a representative assemblage of many beach, dune and links land-forms offering valuable opportunities for studies of coastal evolution.

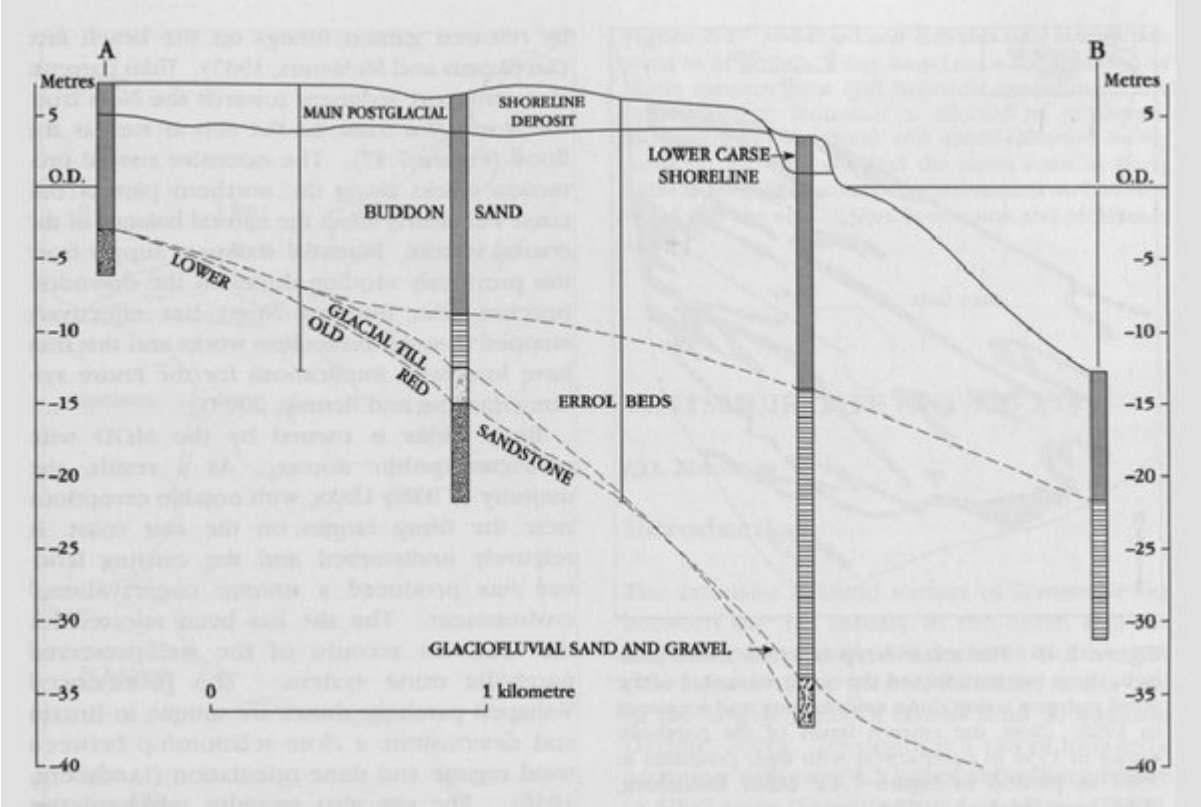


(Figure 7.42) Location of Tentsmuir and Barry Links in St Andrews Bay. Tentsmuir and Barry Links have built out eastward of the main Postglacial (Holocene) shoreline at the mouth of the Tay estuary. Extensive intertidal and subtidal sand banks have also accreted at Abertay and Gaa Sands in the zone where river discharge interacts with open coast tides and waves. (After Ferentinos and McManus, 1981.)

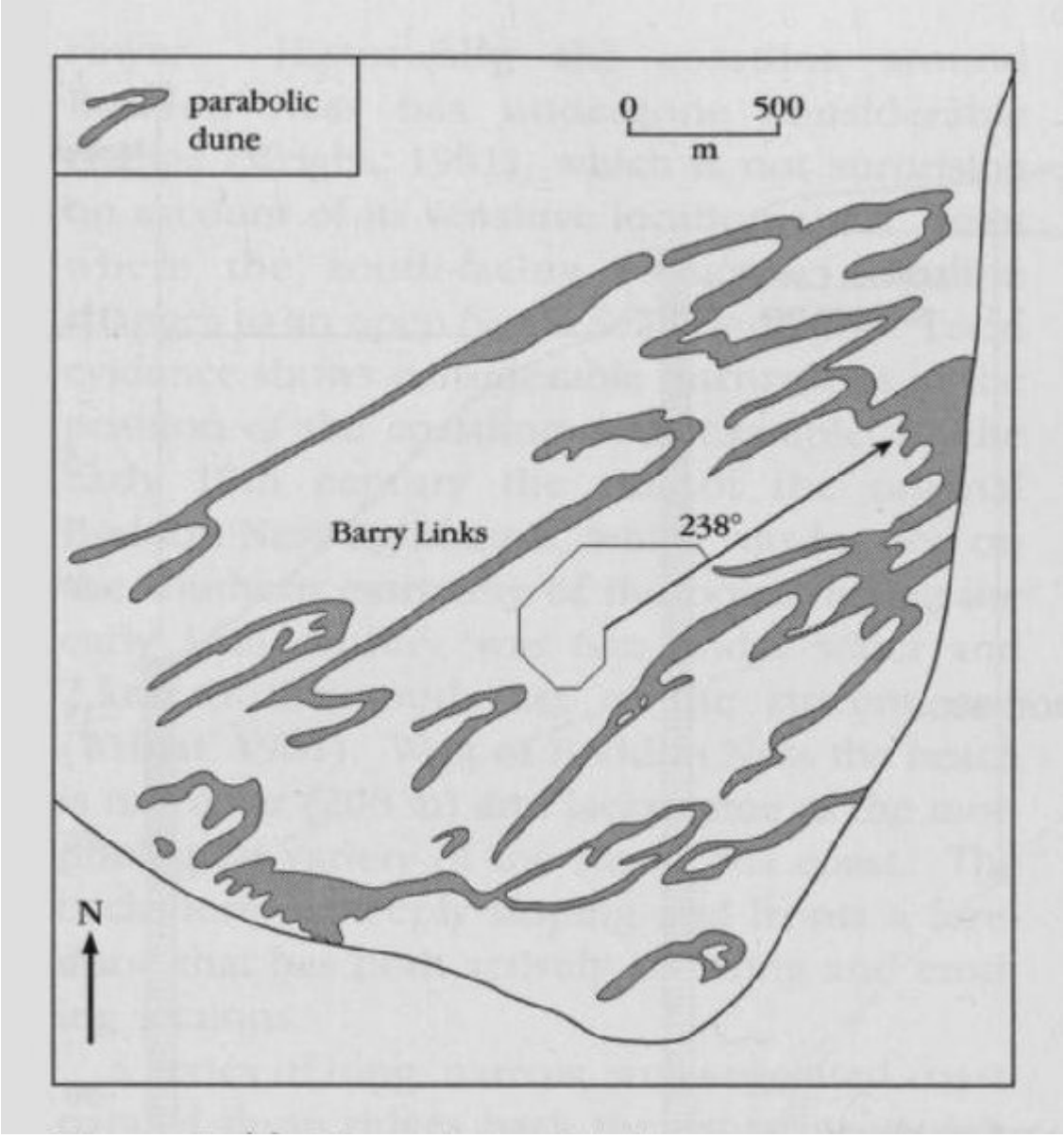


(Figure 7.43) Generalized coastal geomorphology of Barry Links in 1981 showing the erosion of the narrow cordon of recent dunes and the linear nature of the series of older dune ridges, some of which are associated with parabolic forms downwind. As a result of concerns over erosion, a boulder revetment was built in 1992/1993 from the town of Carnoustie to extend along c. 3.5 km of the eastern shore. The section through A-B is shown in Figure 7.45. (After Wright, 1981.)

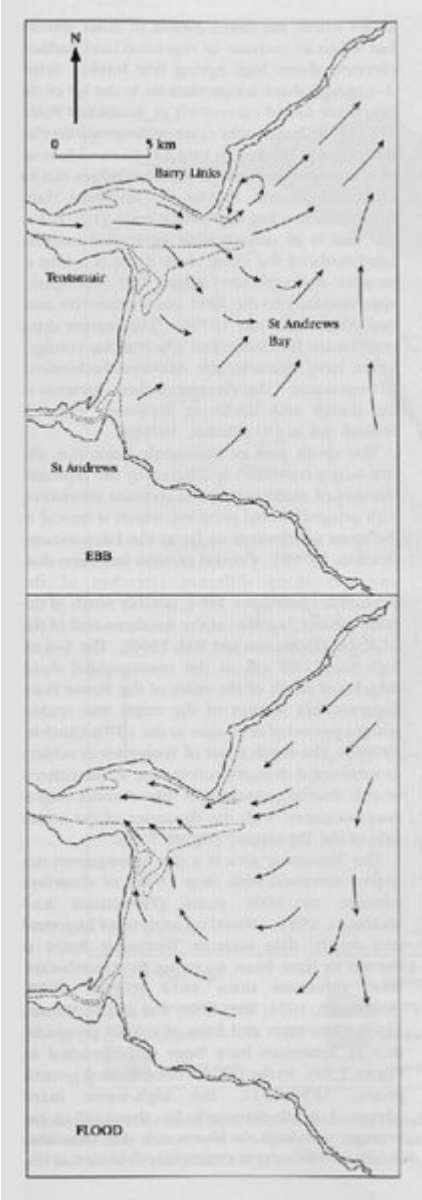
(Figure 7.44) Barry Links looking north showing the high dune edge at Buddon Ness itself and dune ridges of the south (estuarine) side. Clearly visible are the long linear dune ridges, some with parabolic forms, that have been truncated by erosion on the eastern (North Sea) shore. (Photo: P and A. Macdonald/SNH.)



(Figure 7.45) Stylized 3.5 km cross-section (along the line A–B on Figure 7.43) of Barry Links and Buddon Ness as reconstructed from borehole data. Barry Links sits atop substantial thicknesses of marine and shoreface deposits and suggests that this estuary-mouth site has undergone continued deposition over much of the Holocene Epoch. (After Paterson, 1981.)



(Figure 7.46) The relationship between mean parabolic dune orientation and the resultant vector of the wind polygon using dune orientations and locations in 1956. Note the eastern limits of the parabolic dunes in 1956 in comparison with their positions in 1981 as plotted in Figure 7.43. (After Landsberg, 1956, from Hansom, 1988.)



(Figure 7.47) Mid-flood and mid-ebb tidal stream patterns in St Andrew's Bay based on a combination of direct measurement and hydraulic modelling. The open coast at Tentsmuir is affected by northward movement on the flood and south-eastward movement on the ebb, whereas the open coast at Barry Links is affected by southward movement on both the flood and the ebb. (After Ferentinos and McManus, 1981.)