Ainsdale, Lancashire

[SD 285 105]

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Introduction

Much of the coastline of Merseyside and Lancashire is dominated by dunes and very wide intertidal sand and mudflats, but it has also been developed as residential areas and/or resorts, for example Formby, Southport, Blackpool and Morecambe. Serious problems of erosion and coastal flooding have led to parts of the shoreline being strengthened by sea-walls and embankments, and many of the original dune areas have also been damaged or destroyed by afforestation and urbanization. Ainsdale is a National Nature Reserve primarily because of its important dune flora and fauna, but it also includes features of considerable geomorphological importance; predominantly its dunes and the multi-barred ridge and runnel foreshore (see (Figure 7.1) for general location).

Much of the shoreline is affected by erosion, but there are relatively stable bar forms in the intertidal zone. Transport in this zone is predominantly alongshore but has had little influence on the erosion of the shoreline. This contrasts with the effects of changes in the intertidal zone both at Spurn Head and on parts of the Belgian coast (de Moor, 1979). There are many different bedforms displayed upon the foreshore. This is not unusual in itself; but the importance of the site lies in the considerable research that has been carried out. In this respect, it offers an excellent opportunity for comparisons with the sandy shoreline at Gibraltar Point (see GCR site report in Chapter 8) which also lies in a macrotidal environment, but which has a different wave climate.

This coastline was the focus of one of the first regional coastal monographs (Ashton, 1920). Its importance in studies of the evolution of the coastline has been continued to the present time (e.g. Gresswell, 1937, 1953a,b, 1957; Tooley, 1974, 1976, 1978, 1982; Parker, 1975; Kidson and Tooley, 1977; Bird, 1985; Bird and Schwartz, 1985; Innes and Tooley, 1993). In addition, considerable attention has been given to the forms and processes of the intertidal areas and the dunes (e.g. Sly, 1966; Parker, 1971, 1975; Wright, 1976, 1984; Pye and Smith, 1988; Pye, 1990, 1991; Pye and Neal, 1993, 1994; Pye *et al.,* 1995). Unlike many other coastal geomorphological sites, there is also a substantial history of detailed oceanographic investigation in the offshore area (Darbyshire, 1958; Bowden, 1960, Murthy and Cooke, 1962; Lennon, 1963; 2. Lennon, *et al.* 1963; Halliwell and O'Connor, 1966; Belderson and Stride, 1969; Draper and Blakey 1969; Ramster and Hill, 1969). Its ecology is summarized in Atkinson and Houston (1993) and Smith (1999). Hansom *et al.* (1993) reviewed the dune morphology in the context of general erosion and sedimentation patterns in the Ribble estuary area. 3.

Description

The site falls into eight zones (Figure 7.17)a described below as a seaward transect (Parker, 1975):

1. Inland the site is dominated by extensive largely stable dunes that rise to over 23 m OD. Many of the ridges are aligned east–west and generally reach about 16 m OD. Although there are hummocky dunes, true parabolic dunes are poorly developed.
2. To seaward, the dunes are characteristically aligned with the shoreline in a belt up to 200 m wide. They are separated by narrow slacks.
3. An active eroding dune zone up to 80 m in width. Blowthroughs (Parker, 1975), some of which form deep gullies, affect the local movement of sand inland. Damage by trampling also occurs.
4. A narrow, upper foreshore plane area described by Parker (1975) as 'a planar seaward-sloping zone lying between the most landward runnel and the sand dunes at high water mark'.
5. A zone of ridges and runnels, including as many as four ridges, 0.5 m to 1.2 m in height.

6. A lower foreshore formed mainly by intertidal sandflats, which is terminated by a low-water berm.
7. A subtidal slope.
8. Sublittoral sand ridges, 0.5 m to 1.0 m in height with a wavelength of 300 m to 500 m.

Pye (1990) recognized three phases of dune development:

1. Before 1800 — irregular hummocky dunes with incipient blowthroughs and parabolic dunes. These arc fcd by a positive beach sand budget, and with incomplete vegetation cover, prograde gradually seawards.
2. 1880–1906 — a series of dune ridges parallel to the coast were produced by a positive beach-sand budget and sand-trapping vegetation provided by brushwood fencing and marram *Ammophila arena* ria planting. The dunes vary from mobile to semi-fixed, and embryo dunes are still developing where beach accretion occurs.
3. Post-1906 — erosion around Formby Point and disruption of the vegetation cover produced large transgressive sand sheets. These result (Pye, 1990) from: (a) little resistance by vegetation to blowthrough development or to sand encroachment on a broad front; (b) the large directional variability of wind, and (c) the limited development and maintenance of high dunes at Formby because of heavy pedestrian-pressures.

This is a macrotidal environment, with a range at high spring tides of 8.2 m. Occasional surges raise the level of high water (Lennon, 1963). Maximum local waves occur with strong southwesterly to north-westerly winds. The most common waves have a significant wave height of 0.6 m to 1.0 m and a period of 4.0 s to 4.5 s (Parker, 1975). The highest waves may exceed 9.0 m (Murthy and Cook, 1962; Draper, 1966). Pye (1990), however, suggests that severe storm waves with period 8 to 7 s do not exceed 5.7 m in height. The intertidal slope is about 1:244. The dunes include both active and stable areas, though they are generally more stable inland. This stability is reflected in a soil chronosequence that culminates in podzols under sandy heath at Freshfield (Kear, 1985). Slacks are affected by high water-tables. Ranwell (1972) noted that a slack dominated by a mosaic of semi-aquatic plant communities described by Blanchard in 1952 was being threatened by erosion of the dunes on its seaward side. As a result of such changes in the dune morphology, former slack deposits appear from time to time on the foreshore. Fossil dune slacks have been identified on Formby foreshore (Tooley, 1976). Holocene silts and clays underlie the foreshore and affect the drying and wetting of the sand ridges. They are commonly exposed in the runnels. At Downholland Moss marine transgressive and regressive overlaps were dated to 6890 ± 55 years BP and 6790 ± 95 years BP at –0.87 m and –0.36 m OD (Tooley, 1976). Tooley (1978) refined this interpretation, recognizing five periods of marine transgression designated as Downholland I–V, with radiocarbon dating of key horizons as index points for sea level (Tooley, 1978).

Parker (1975) described the main processes working on both the active dunes and the foreshore. Only limited sand from the foreshore is fed directly to the dunes because even though the ridges dry, blowing sand cannot reach the dunes where the runnel between the most landward ridge and the plane area remains wet at all times. Landward sand movement from the ridge and runnel zone to the dunes is blocked. Sand is blown from the plane area along the face of the dune cliff to travel inland along the gaps in the ridge. Erosion of the sand cliff is strongly associated with wave undercutting (Figure 7.18). Most rapid retreat occurs when tides exceed +5.2 m OD. Lennon (1963) showed that tides in excess of this level are rarely produced by undisturbed astronomical tides, and so most erosion of the sand cliffs appears to be associated with storm surges at high water. In the foreshore area, the underlying Holocene sands and silts are often exposed in the runnels. They are eroded as the beach ridges move across the foreshore. The coastal profile between high and low-water mark is retreating under wave conditions that commonly approach the beach at a large angle. Retreat of the shoreline is thus associated with the processes that affect longshore sand movement and lead to lowering of the foreshore.

On the multi-barred foreshore, waves and tidal streams are the most important sources of energy for the movement of sediment, together with the abundance of sand and the influence of the short fetch on wave length. Breakers are dominant on the ridges, whereas currents (both wave-induced and tidal) predominate within the runnels. Sediment transport is predominantly alongshore within the runnels, but there is only limited movement onshore. Parker (1975) commented on the lack of understanding of the role of mud in processes of sub- and intertidal sedimentation. He found little evidence to support the suggestion (Robinson, 1964) that some channels are dominated by ebb flows in contrast to others that are dominated by flood-tide flows.

Interpretation

The general form of Ainsdale has come about as a result of progradation associated with sea-level rise. Sea floor deposits of sand were gradually transported landwards to broadly their present-day positions between 5000 and 7000 years BP (Figure 7.17). In this it is similar to many of the features of the coastline of England and Wales. It attains its status as a member of the network of coastal dune GCR sites in the dynamism of present-day processes that affect changes in the shoreline, the intertidal area and ultimately the stability of the dune system. The role of sea-level change, the development and breaching of coastal barriers and progressive sedimentation have been the subject of local reports since the 17th century (Binney and Talbot, 1843; de Rance, 1869, 1872, 1877, 1878; Reade, 1872, 1881, 1902, 1908). During the early 20th century there were many studies of the biogenic sediments (Travis, 1908, 1922, 1926, 1929; Erdtman, 1926; Blackburn in Cope, 1939) and the stratigraphical record (Cope, 1939; Wray and Cope, 1948; Hall, 1954–1955). Gresswell (1937, 1953a,b, 1957, 1964) developed a model of coastal evolution based on an initially low sea level about 18 000 years BP followed by rapid sea-level rise to about 5000 years BP Subsequent glacio-isostatic uplift caused the shoreline to retreat westwards and the sandy coast developed as a regressive wedge (Gresswell, 1953a). Gresswell (1953b) identified the former coastline of southern Lancashire at about +5.2 m OD, his 'Hillhouse Coast', but this was rejected by Tooley (1978) who argued that evidence for this former coastline was seriously flawed. Tooley (1976) showed that in the Martin Mere basin, the 'Hillhouse' coastline is not related to a marine event, but to a period of elevated lake levels.

Since Gresswell's work, the palaeogeography has been comprehensively reconstructed (Tooley, 1969, 1970, 1971, 1973, 1974, 1976, 1977a,b, 1978, 1982, 1985a,b; Tooley and Kear, 1977; Huddart and Carter, 1977; Huddart, 1992; Innes and Tooley, 1993; Pye and Neal, 1993). Tooley (1974) for example suggests that most of the constructional landforms of the Lancashire coast, such as the shingle spits, sandbars and sand-dunes (of which Ainsdale is the outstanding remaining example), were associated with extensive transgressions (probably four or five according to Tooley, 1978) from 9200 years BP to 5000 years BP Estuarine and salt-marsh environments resulting from the transgressions before 4500 BC are preserved as the Downholland silt as much as 2.2 kin inland. Although Huddart (1992) argues that there was an early barrier, a view supported by Pye and Neal (1993), Tooley (1978) and Innes and Tooley (1993) consider that although early sedimentation occurred, the main development of the sand dune barrier took place about 5000 years BP A slightly lower sea level allowed large-scale transport of sand from the exposed intertidal and nearshore areas, probably a large offshore sandbank that was in place by 6800 years BP (Pye and Neal, 1993), to form the dunes. The seaward edge of Downholland Moss (now about 4 km from the coast) was covered by sand about 4090 ± 170 years BP (Tooley, 1978) and peat deposits at Sniggery Wood were probably buried about 4510 ± 50 years BP (Figure 7.17). 'Fossil' dune slacks or peat exposed within the beach have been dated (for example the former at Formby dated at 2335 ± 120 years BP and 830 ± 50 years BP: Tooley 1978; Innes and Tooley, 1993 and the latter at Alt Mouth at 4545 ± 90 years BP and below low tide level dated at about 8000 years BP: Tooley, 1978). Innes and Tooley (1993) summarize the pattern as follows:

1. An initial period of sand migration and dune-building between 4600 and 4000 years BP
2. After several centuries of sand migration, a coastal dune in place by 4000 years BE
3. Continuing sand accumulation interrupted by marine transgressions about 3500, 2335, 1795–1370 and 800 radiocarbon years BP
4. A recent erosional phase.

The present erosional phase is generally identified as commencing at about the beginning of the 20th century. It is reworking a substantial store of sand, but the predominant movement is offshore. Sly (1966) suggested that the area off Formby Point was marked by a divergence of bed load transport, and Ramster and Hill (1969) identified it as a zone of divergence of near-bed residual water drift. Hansom *et al.* (1993) studied positions of LWST and HWST at Formby Point to demonstrate erosion at LWST and accretion at HWST over the period 1841–1946, and erosion at both LWST and HWST between 1946 and 1989. Since 1906, 400 m has been lost at Formby Point with attendant foreshore steepening. This erosion has fuelled accretion in the Ribble to the north. Ainsdale has been more severely affected by erosion than other dune systems of the west coast. This appears to result in part from storm surges in the northern Irish Sea, and especially in the Mersey estuary, which affect the patterns of shoreline erosion. Between 1842 and 1906, accretion dominated. Between the 18th century and the early 20th century, the climate was relatively quiescent in terms of storm events (Lamb, 1982). Although Binney and Talbot (1843) suggested that storm events were probably the most important formative events for the evolution of this coast, sea-level rise has until recently been the more favoured explanation (Pye, 1991, 1992). Plater *et al.* (1993) however, demonstrate that storm surges have played a critical role in the erosion of the dune frontage and also in the sediment transport dynamics of the Formby-Ainsdale coast (Figure 7.18). Since about 1900 the whole frontage of about 5 km has been eroded by up to 3 m a^{-1} (Pye and Neal, 1994). However, single storm events can cause the dunes to retreat between 6 and 14 m (Pye, 1991). The high frequency of strong westerly winds has been a factor, but the construction of training walls and the dumping of spoil offshore has also played a role by focusing wave energy onto the north-central part of Formby Point (Pye and Neal, 1994).

The site is well known for its many smaller-scale features in the intertidal area, and has been the key site in Britain for the description and interpretation of ridge and runnel forms. The coastline at Blackpool and Ainsdale to its south were the location of extensive studies into the interpretation of aerial photographs prior to the Normandy landings in 1944 (Williams, 1947; King and 'Williams, 1949). At this time, King developed her swash-bar interpretation of ridge and runnel on equilibrium-seeking beaches, which was further elucidated in 1972 and 1982. Wright (1976) and Orford and Wright (1978) showed that, on the basis of detailed studies at Ainsdale, ridges and runnels as quasi-stationary features resulting from swash processes could be distinguished from breakpoint bars and troughs associated with breaking waves. More recently, Orme and Orme (1988) have argued that three models for ridge and runnel formation can be identified:

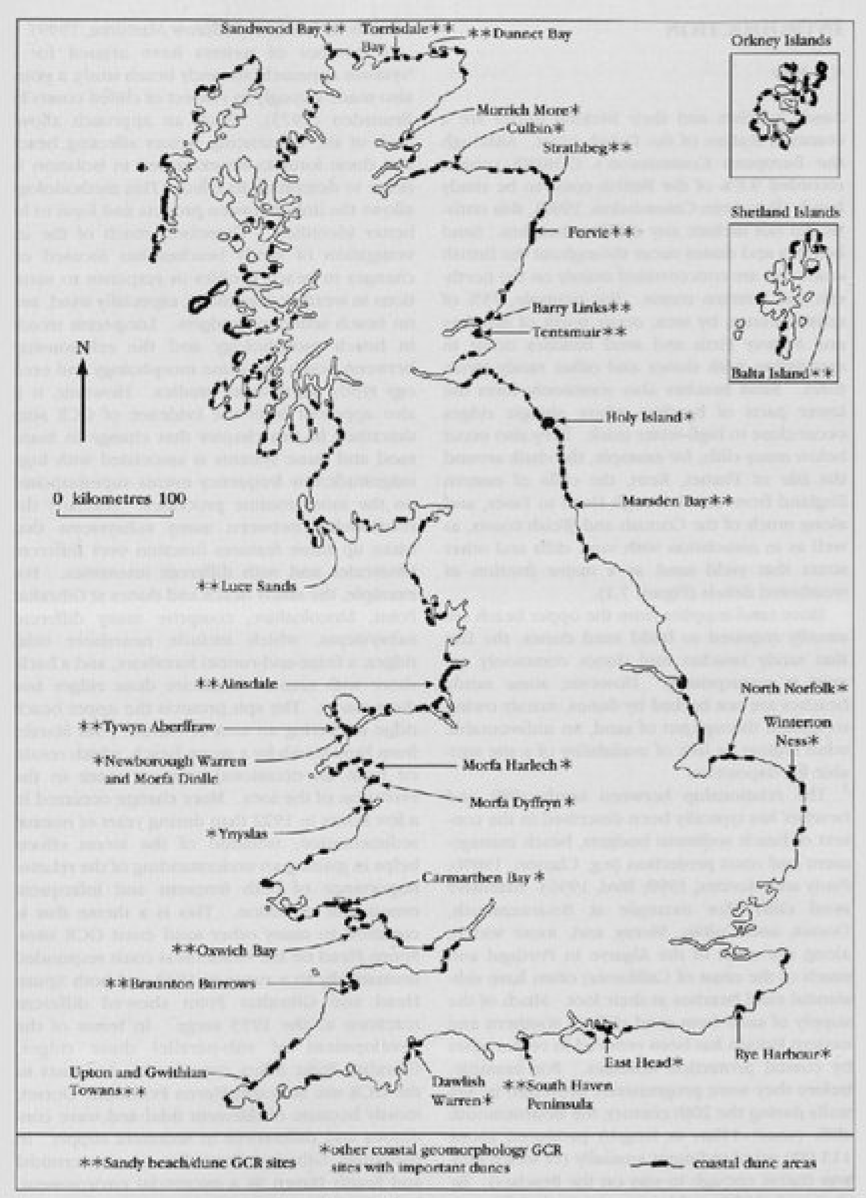
1. Swash-bar deposition of ridges. This follows King's (1959) model, but is most common in macrotidal areas.
2. Ridges and runnels result from the onshore migration of longshore bars and troughs.
3. Runnel erosion rather than ridge accretion can also occur. This appears unlikely at Ainsdale because of the role of the muddy subsurface in sand movements.

The contrast between the shore-parallel dune ridges and the west-east alignment of dune ridges farther inland suggests that the role of blowthroughs is important. As these semi-mobile dunes become stabilized by vegetation, they become fixed features of this landscape. A specific issue that warrants further research is the extent to which this fixed linearity is established with the development of each new seaward ridge and its associated slack.

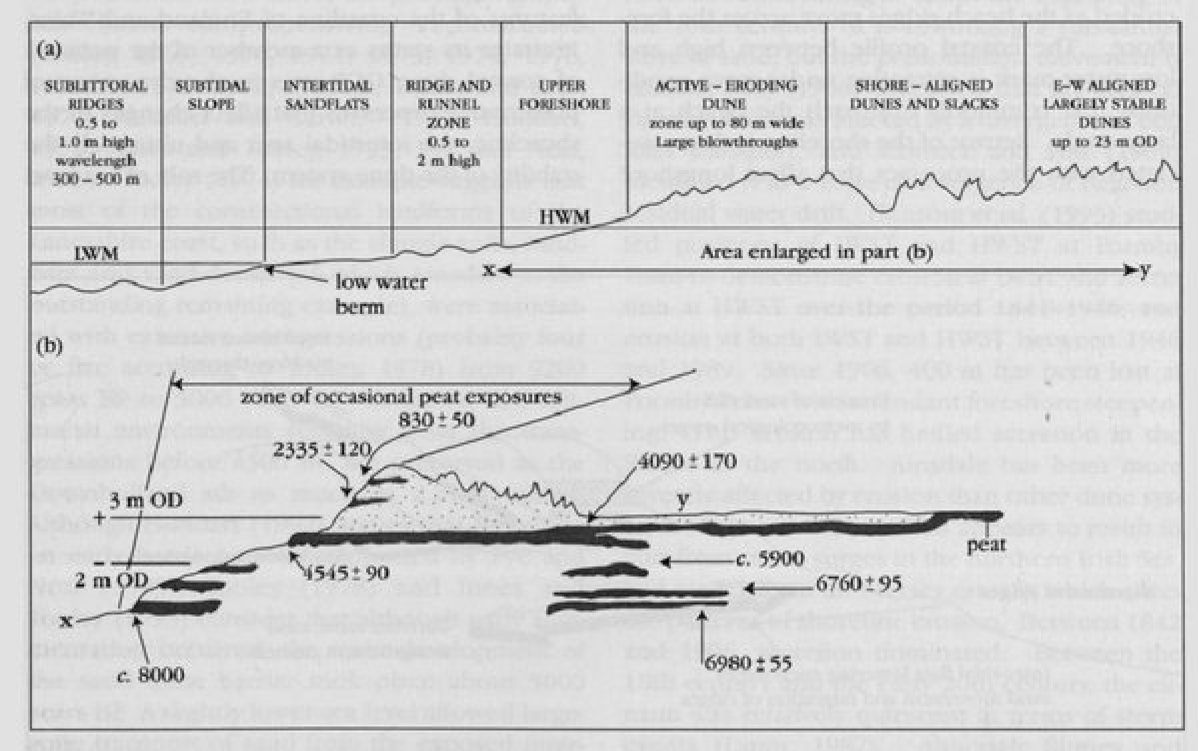
Conclusions

Ainsdale is a nationally significant site in that the development of this extensive dune system depends upon not only long-term changes during the Holocene Epoch, but also on the detailed effects of surges, sand movements and especially the ridge and runnel of its multi-barred foreshore; it could be regarded as the type area for such forms in Britain. Ainsdale greatly increases our understanding of coastal processes and their relative roles at many different time and space scales. The detailed interpretation of the Holocene history means that this site is of international significance for understanding of the effects of changing sea levels during the Holocene Epoch. In addition, the detailed monitoring of the site provides a nationally important location for the development of strategies for coastal management in the face of global climate change.

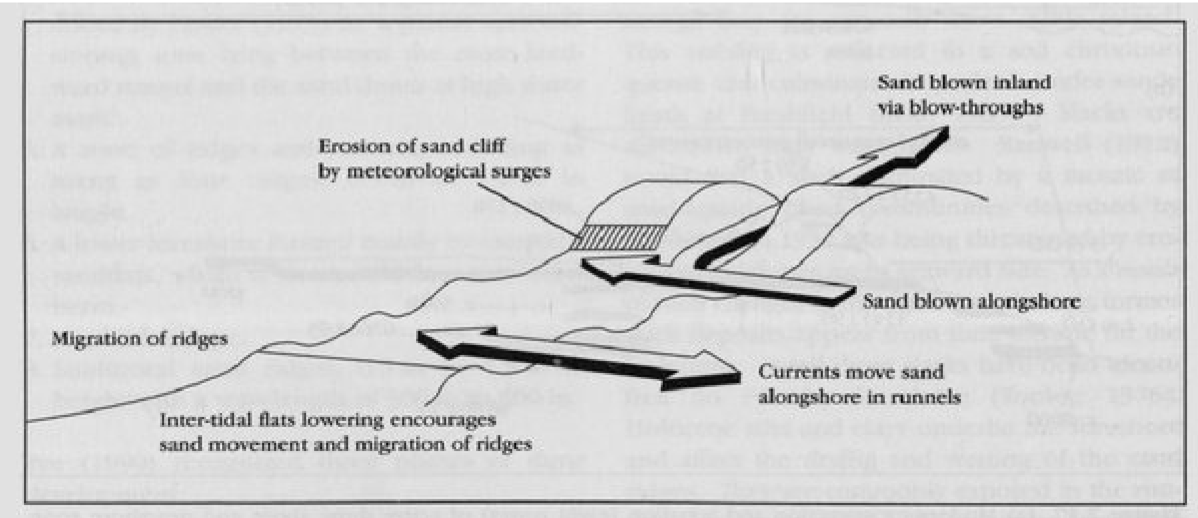
One of the three largest dune systems of the west coast of England and Wales, Ainsdale is a National Nature Reserve because of its dune flora and fauna, but its coastal geomorphological interest is considerable. The place of Ainsdale in British coastal geomorphology is very significant, for research has focused on both the present-day processes and the changes during the Holocene Epoch and it provides a key site for interpretation of coastal change in northwestern England.



(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.



(Figure 7.17) (a) Modern cross-section and zonation (eight zones) of active dune shore and nearshore zone. (After Parker, 1975.) (b) Historical schematic summary of dated peats. (After Tooley, 1978.)



(Figure 7.18) Dune-front processes at Ainsdale.