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# Machir Bay, Islay, Argyll and Bute

[NR 210 630]

## Introduction

Machir Bay is a highly dynamic beach–dune–machair assemblage located on the exposed Atlantic coast of Islay (see (Figure 9.1) for general location and (Figure 9.5)). The wide, high-energy beach is backed by a complex sequence of dune forms including low embryo dunes, an active foredune ridge, multi-ridged mature dunes, re-depositional sandhills and an extensive machair surface. The machair plain is of exceptional geomorphological interest as it drapes a number of topographical features including a series of high-level marine terraces, glacial deposits, talus slopes, and rock plateaux. Many streams drain through the dune and machair providing a strong hydrological control on morphology. Although several descriptions exist of the beach–dune–machair morphology of Machir Bay (Ritchie and Crofts, 1974; MacTaggart, 1996), greater interest has been shown in the emerged beaches, glacial terraces and relict clifflines that the machair partially obscures (Dawson, 1983; Dawson *et al.*, 1997).

## Description

The 2.1 km-long beach at Machir Bay on the exposed Atlantic coast of western Islay has an open south-west fetch and lies within a SW–NE-trending structural basin of Torridonian sandstone that represents an extension of the Loch Gorm depression. There is also widespread evidence of glaciation and the deposition of substantial quantities of glaciogenic materials both onshore and offshore. For example, till, moraine and various glaciofluvial and glaciomarine deposits are common on Islay (Dawson *et al.*, 1997). At Machir Bay, a relict cliff cut in Torridonian sandstone forms the southern margin of the bay, whereas the northern part of the bay is generally lower and merges into the flat plateau of the interior. A relict cliff cut in terraced glaciomarine gravels (Dawson *et al.*, 1997) at 23 m OD extends towards the north-west end of the Bay and lowers westwards with an average gradient of  $9.8 \text{ m km}^{-1}$  (Dawson, 1983). Although a conspicuous feature, it is partially obscured by a veneer of windblown sand that comprises part of the machair. The terrace is succeeded farther south by a smaller terrace fragment, also interpreted as outwash, which declines in altitude and terminates at an emerged ('raised') shoreline at 21.4 m OD (Dawson *et al.*, 1988). As a result of the occurrence of preexisting terrace and cliff topography, the dune and machair landform assemblage of Machir Bay is asymmetrical in form being best developed in the south and east of the site.

The wide intertidal beach has a low gradient of  $1\text{--}2^\circ$  and is composed of medium-grade sand (0.23 mm mean diameter) with a calcium carbonate content of 34%. The beach exhibits considerable variation in profile and plan (Ritchie and Crofts, 1974) but the upper 20 m is rarely covered by seawater. The 3 m tidal range results in a 0.32 km-wide expanse of bare sand, broken only by the rocky intertidal outcrop of Carrig Chomain in the south. Extensive areas of aeolian sand ripples were noted on the beach face in July 1996 providing evidence of a sand supply to the dune system behind (MacTaggart, 1996). Two streams, the Allt Gleann na Ceardaich and the Allt na Criche, cross the beach in the centre and north of the bay. At the rear of the beach, the foredune ridge shows signs of periodic undercutting by storm waves at high tide, although subsequent deposition of embryo dunes partly obscures the erosional faces.

The foredune ridge landward of the beach is best developed in the south, where it reaches 15 m high and displays steep seaward slopes of around  $20^\circ$ . The dune face and crest are extensively covered in vigorous marram *Ammophila arenaria* growth, and this broad coastal dune continues, curving slightly inland, to the stream outlet in the centre of the bay. Ritchie and Crofts (1974) report that the frontal dunes are characteristically devoid of breaches or erosional hollows. However, a more recent report (MacTaggart, 1996) identifies a large, but relatively shallow, blowthrough in the foredune ridge close to the centre of the bay and several healed blowthrough forms farther south, indicating that foredune erosion may now be a more significant process than before. There is extensive evidence of local wave-erosion of the dune face, particularly in the south of the site (MacTaggart, 1996), and during the winter storms of 1989, the dune face receded by an estimated 5–10 m (MacTaggart, 1996). Fresh sand accumulations and low embryo dunes masked the lower slopes of the

foredunes in July 1996 (MacTaggart, 1996).

Between the stream outlets the coastal edge consists of a 3 m-high dune ridge developed seawards of an older dune ridge (Ritchie and Crofts, 1974). Marram *Ammophila arenaria* colonization is patchy, and localized areas of erosion exist north of the outlet of the Allt Gleann na Ceardaich. No dunes occur north of the marshy outlet of the northern stream but instead a low altitude sand platform with a maximum altitude of c. 2 m slopes gently seawards onto the beach face and is vegetated for some distance down the beach face.

Older dunes and re-depositional sandhills are present landwards of the active dune ridge and again are best developed towards the south and south-east of the bay. A linear dune ridge seaward of the active foredune ridge is well defined in the centre of the bay (MacTaggart, 1996), while farther inland several other relict dune ridges trend north-west to south-east (Ritchie and Crofts, 1974). Smaller dune forms and ridges, blowthroughs, erosional scars and re-depositional forms add topographical diversity to this dune complex, which has an average relief amplitude of 5–10 m, although altitudes exceed 20 m OD in places (Ritchie and Crofts, 1974). At the base of an active blowthrough in this area, and in other blowthroughs within the dunes, MacTaggart (1996) identified outcrops of indurated acolian calcarenite, blown sand cemented by the precipitation of calcium carbonate from subsurface water. In the south a distinctive amphitheatre-like depression supports a variety of machair and relict dunes on its sides and is floored by a semi-permanent, marshy loch (Figure 9.5).

The extensive machair at Machir Bay can be classified according to topographical situation. In the south, a series of fan-like deposits cover the face of the relict rock cliff as well as the screes beneath. Sand deposits banked against the relict cliff have been eroded to form a terrace feature. An extensive machair plain some 50 m above sea level has developed on the plateau surface of the glaciomarine gravel terrace cut into till and extending as far inland as the old church of Kilchoman. This plateau machair is predominantly stable, although characterized by several areas of bare sand (Ritchie and Crofts, 1974; MacTaggart, 1996). Higher areas of machair at up to 60 m OD have developed in ledges or depressions in the rocks to the south of the site. In the northern part of the site the machair surfaces are generally more subdued and high relief forms are rare. Numerous streams drain into Machir Bay, crossing both dunes and the cliffs in the south, resulting in an elevated and fluctuating water table that adds to the geomorphic diversity of the machair and dune forms. The two streams that cut across the beach in the centre and north of bay are responsible for locally high water-tables that form the base level for deflation of the dunes and machair.

## Interpretation

Machir Bay contains a great variety of dune and machair forms, probably the result of the strong control of structure, subsurface morphology and hydrology and the dominance of winds from the north-west. It is this variety of dune and machair landforms and their relationships to a variety of geographical controls that is of outstanding geomorphological significance. The relatively undisturbed nature of Machir Bay provides an excellent opportunity to study the evolution of a variety of dune forms and the effects of water table and drainage controls on morphology, but as yet no detailed geomorphological research has been undertaken.

The emerged marine terraces and glacial deposits of Machir Bay have attracted greater scientific interest in the context of the Quaternary evolution of Western Isles of Scotland (Dawson, 1983). The coarse gravel terrace that underlies the extensive machair plain has been interpreted as a Lateglacial glaciomarine deposit that graded to a sea level lower than c. 23 m OD during the decay of the last ice sheet (Dawson, 1983). The terrace declines in altitude westwards at an average gradient of 9.8 m km<sup>-1</sup> towards Machir Bay where it passes beneath accumulations of blown sand. The terrace is succeeded farther south by a smaller Lateglacial terrace fragment, also interpreted as glaciomarine, which declines in altitude and terminates at an emerged shoreline at 21.4 m OD (Dawson, 1983).

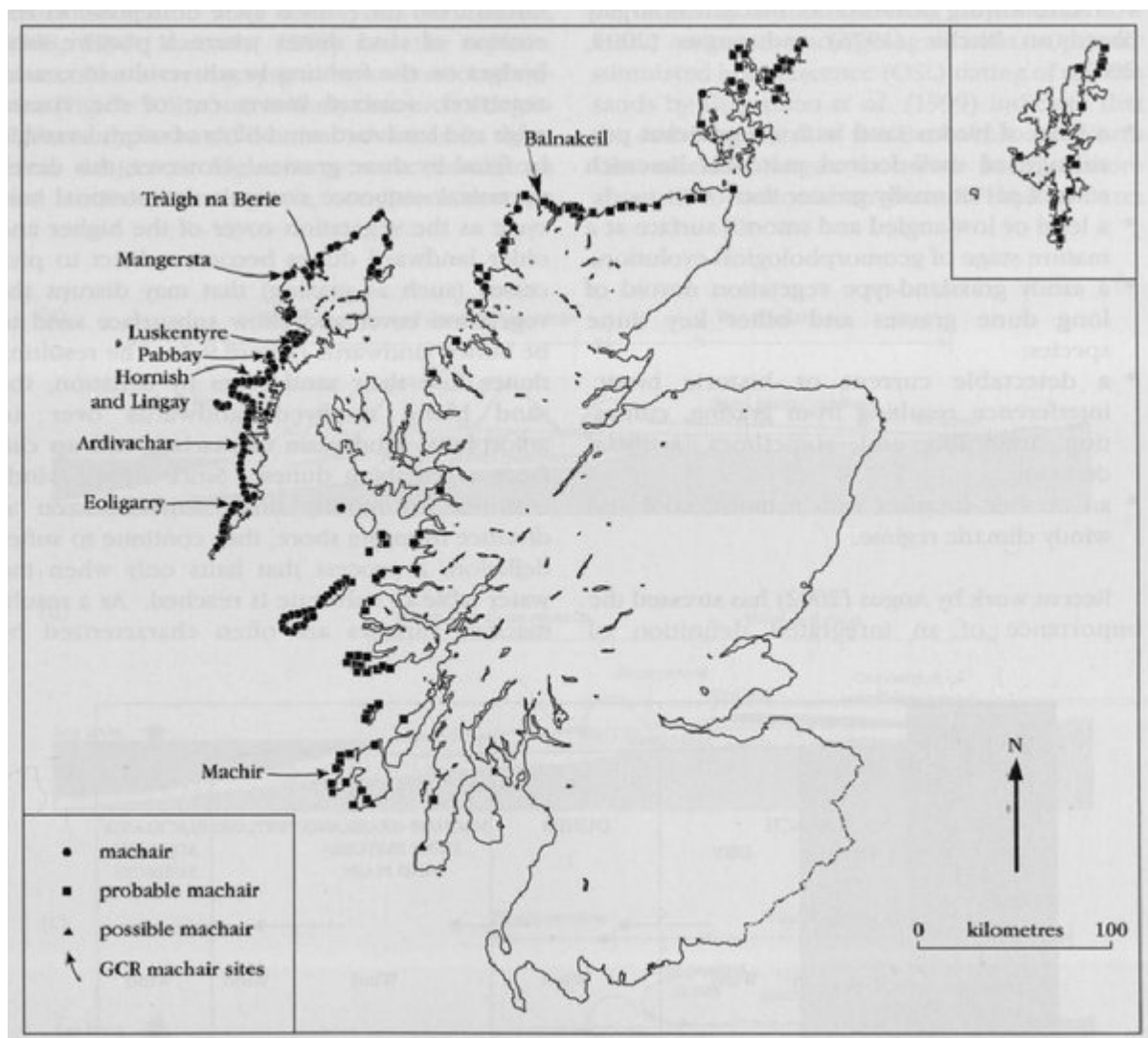
In the period following deglaciation, rapid sea-level rise inundated many of the coastal bays on Islay and at Machir the lower parts of the southern rock cliffs and central glaciogenic deposits were re-occupied by the Holocene sea. Glaciogenic sediments available on the seabed were likely driven onshore to accumulate in sandy beaches such as those at Machir Bay. The subsequent process of sand delivery to the dunes and machair at Machir Bay is similar to that outlined for the Outer Hebrides (Ritchie, 1979a), but in Islay sea levels were falling in Late Holocene times. The late

Holocene decline in sediment supply noted elsewhere in Scotland was delayed in Islay as a result of ongoing iso-static uplift that allowed waves to access new areas of sea-floor sediment while progressively elevating the rearmost coastal features by c. 8 m over 6500 years. This resulted in the dune and machair landforms of Machir Bay being draped over pre-existing structures and deposits up to 60 m OD. The dominance of strong winds from the north-west also contributed to the apparent asymmetry in the distribution of windblown sand and imparted a strong southerly bias to this distribution. The machair and dune forms also reflect the strong hydrological and water-table controls of the Machir Bay basin, in particular around the depression in the south and close to the streams that cross the beach.

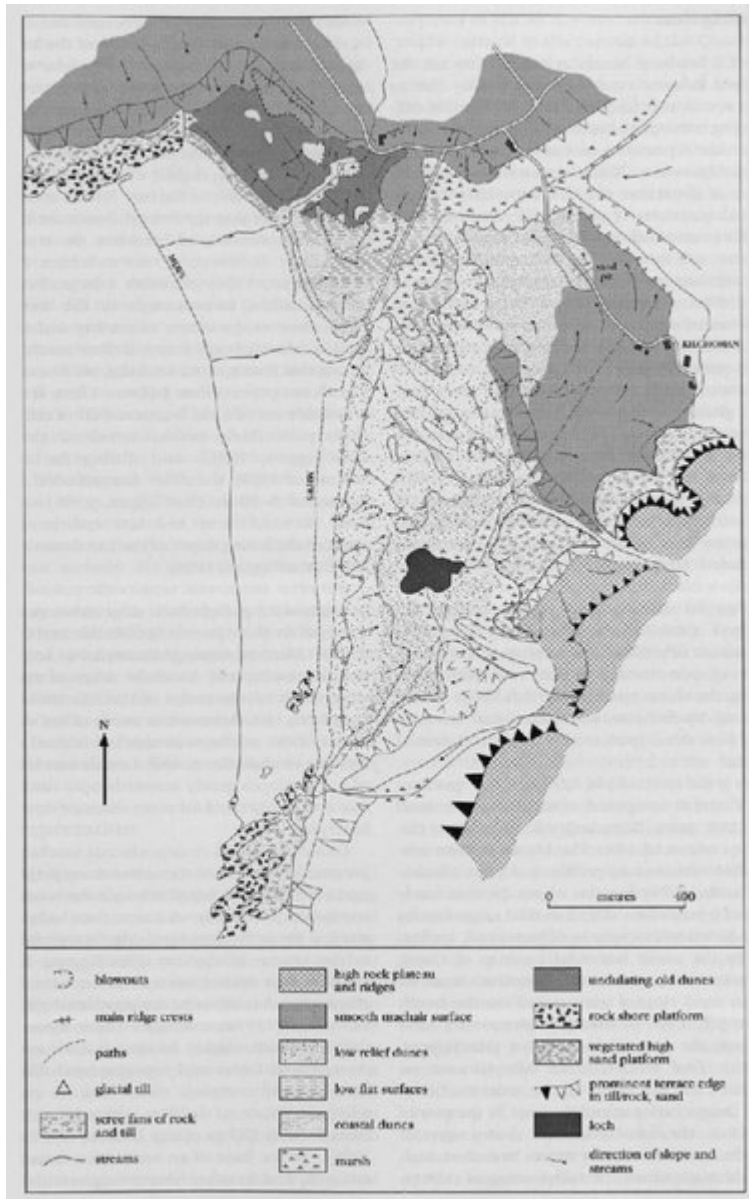
At present the coastal dunes at Machir Bay are undergoing a period of erosion. Frontal dune erosion appears to be caused by storm wave action undercutting the dune face, causing slumping of the vegetation (MacTaggart, 1996). However, it is unclear whether this is the seasonal effect of winter storms. Ritchie and Crofts (1974) suggested that Machir Bay was stable or accreting but MacTaggart (1996) observed that the foredune ridge was almost everywhere undergoing frontal erosion and that this appeared to contribute to blowthrough initiation and dune instability. However in the north, the continued extension of vegetation onto the low area at the back of the beach indicates that, in this sheltered part of the bay, accretion still occurs.

## Conclusions

Machir Bay on the exposed Atlantic coast of western Islay is an excellent example of a well-developed and topographically diverse beach–dune–machair system. The site contains a great variety of dune and machair forms, as a result of the control of subsurface morphology and hydrology, and the dominance of winds from the north-west. The machair, which reaches altitudes of c. 60 m OD, is of exceptional geomorphological interest as it drapes a number of topographical features including a series of high-level glaciomarine terraces, talus slopes and rock plateaux.



(Figure 9.1) Distribution of machair in Scotland. Other than Sandwood, Torrisdale and Balta (see Chapter 7), all the sites included in the GCR fulfil both the geomorphological and vegetational definition of machair. Small vegetational differences in the above sites have resulted in the label 'probable machair'. Ongoing work that interprets the geomorphology and botany of machair aims to provide a definitive machair diagnostic test in the future and so the above classification will be subject to slight modification (Angus, 2003, pers. comm.). (After Hansom and Angus, 2001.)



(Figure 9.5) Geomorphology of Machir Bay, Islay, showing a mix of machair types including substantial terraces at the rear of the system covered by high machair. (After Ritchie and Crofts, 1974.)