SCOTTISH NATURAL HERITAGE

COMMISSIONED REPORT

Beaches of Sutherland

A survey of the beach, dune and machair areas of north and west Sutherland

Commissioned by the Countryside Commission for Scotland, 1969.

W. Ritchie and A. Mather

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Preface and Acknowledgements

The authors would like to record their appreciation to many people who made it possible to complete this report from fieldwork to printing in the space for four months. Professor K. Walton gave continuous encouragement and advice during the course of fieldwork and in the process of interpretation and presentation of the information. All the photographs published in the report and many others which will be held as a photographic inventory of the beach areas were also taken during this period by Professor Walton.

Facilities for research were also provided by Sutherland County Planning Office, The Northern Times, the Aerial Photographs Library (Edinburgh) and the Crofters' Commission. Township clerks, local inhabitants and estate factors also provided important information.

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Miss S. Bain	Mr J. Livingstone	Mr D. Robertson
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October 1969

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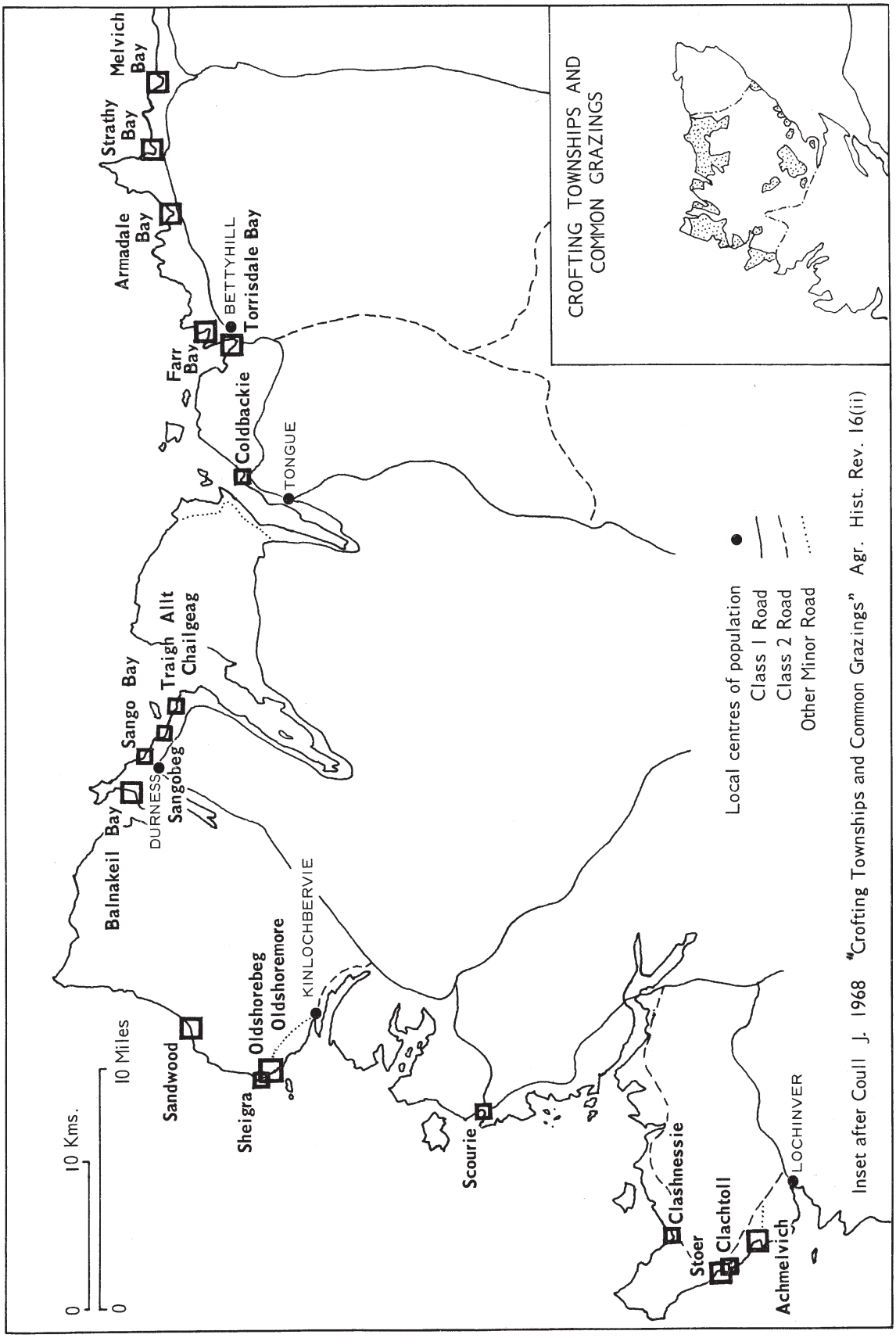


1. The General Setting

Background to the Survey

For some years Sutherland County Council have been aware of grave problems concerning the use of certain beach areas in the county as caravan sites, and the rapid physical deterioration of some of these beach areas. The realisation that such deterioration has been taking place has been acknowledged since the early 1960's, and in 1968 the County Planning Officer prepared a report on the Development of Caravan and Camping Sites, in which he stressed that some of the beach areas appeared to be subject to misuse. The report was forwarded to the Countryside Commission, who were able to confirm the severity of the problem. At first it was planned to employ student labour perhaps over several years to analyse the situation, but the Countryside Commission concluded that the urgency of the problem necessitated more rapid action than the County Council had been able to contemplate, and agreed to support an investigation during the summer of 1969. The Countryside Commission felt that it was appropriate to be associated with such an investigation not only because it is likely that it will be consulted at some stage in allocating grants for caravan site development, but also because it felt that some of the beaches were of national rather than local interest. Consequently, the Countryside Commission, in exercise of their powers under Section 4(c) of the Countryside (Scotland) Act 1967, commissioned Aberdeen University Geography Department to undertake an inventory of certain selected beaches with a view to providing the Commission and the Local Planning Authority with basic data for conservation and recreation development planning. The beaches which were specifically to be investigated were Achmelvich, Clachtoll, Stoer, Clashnessie, Scourie, Oldshore More, Sandwood, Sheigra, Balnakeil, Coldbackie, Farr Bay, Armadale, Strathy and Melvich. In addition to these beaches, Torrisdale Bay, Oldshore Beg and a number of small, although popular beaches near Durness were also investigated. The Department was instructed to report on the following factors for each beach involved.

(a) Physical characteristics of beaches and materials to the landward limit of maritime activity; this physical assessment will form the core of the report.
(b) Vegetation.
(c) Grazing.
(d) Ownership and land tenure.
(e) Recreational use.
(f) Scientific and scenic conservation value.
(g) Dynamics and rate of change.
(h) Accessibility, water supply and other factors as appropriate.

In addition to these descriptive considerations, the Department was invited to provide:

(a) A synoptic assessment of the above points.
(b) Any suggestions they might wish to make on conservation, future recreational provision, carrying capacity and access or any other appropriate matters on which they may wish to comment.

The Beaches and the Problem

The mainly rocky north and west coasts of Sutherland are broken at intervals by small areas of beaches,

frequently composed of sand of a high shell content. These beaches are scenically very attractive, offering contrasts of texture and colour to the generally rather harsh but spectacular mountain and rock scenery. They thus prove attractive to tourists, not only because of their visual quality, but also because of their recreational potential, especially for children. Certain of the beach areas have become popular caravanning places, but unfortunately there is evidence of overuse in some places in the absence and difficulty of planning controls. This investigation was thus stimulated by a realisation that the beaches of Sutherland were valuable resources, the more so because of the relative paucity of most other resources in the county, on which a considerable sector of the tourism industry depended, and by a wish to conserve these resources for future, as well as present use.

2. Purpose and Methods of Study

The purpose of this report is to present a body of information on the nature and use of the low, unconsolidated, beach fringed coastal zones in Sutherland. The report forms a *resource-inventory* which may be used as an integral part of any discussions concerned with conservation, land use or future recreational and tourist developments in the county.

Since this resource consists basically of landscape elements the presentation is largely in the form of large-scale maps supplemented by descriptive text and where applicable photographs. Quantitative information, as for example about the nature of the beach and dune sand, is given in appendices.

The principal technique used was large-scale (1:5,280 and 1:2,640) landform mapping in the field. Simultaneously to assure consistency of approach notes on variables such as special wave or tide conditions, vegetation, general structure, exposure index and evidence of current processes were recorded on standard index cards (see sample overleaf). Observations of slopes were noted and sand samples were taken for subsequent analyses. If possible, interviews were sought in the area with the township clerk and estate offices. Field investigations were supplemented where appropriate by relevant documentary material.

3. General Physical Factors

Geology

The landforms of Sutherland of which the beaches form but a small part are developed on a geological framework as varied and visually exciting as anywhere in Europe. The great Moine thrust plane separated the varied Moine series of ancient metamorphic rocks from the Lewisian, Torridonian and Cambrian rocks of the west. The main rock types are shown in Figure 1a and the basic division between the discordant, fretted coastline east of Loch Eriboll and the fiord and cliff coastline of the massive ancient strata of the west is readily apparent. A further sub-division may be made south of Loch Laxford where series of intrusive dykes and veins run through the country rock in a generally W.N.W.–E.S.E. direction.

For this study, however, the local geological situation is more important than the macro-framework. It is the small-scale feature such as a local fault or joint-plane, or the juxtaposition of softer against harder beds or the susceptibility of a specific layer to weathering that is the cause of coastal diversity. Equally, in the final analysis, bedrock is the source of the sand and shingle which infills the topographical depressions and gives rise to the beaches, dunes and machair. In this context a basic division exists between the gneisses, schists and other igneous rocks which are generally extremely hard and durable, and therefore resistant to current morphogenetic processes and the softer conglomerates and sandstones of either Torridonian or Old Red Sandstone Age which tend to supply shingle and sand for coastal development. A special group of rocks are the limestones, notably around Durness, which can be subject to erosion by solution.

But such is the diversity of the rocks of Sutherland that generalisations are unwise and the part played by solid geology in the evolution of those parts of the coastline which are described in the report can only be described on a local basis in due course.

Regional Landforms and Glaciation

The landforms of Sutherland consist of a series of erosion surfaces or plateaux diversified by igneous masses such as the syenite of Ben Loyal or the residual peaks such as Quinag or Ben Stack with their protective cap of Cambrian quartzite. Into these high desolate surfaces two drainage patterns have been cut. Along the north coast the long overdeepened southwest-northeast or south-north valleys such as Strath Halladale, Strathnaver and the Kinloch River are the main drainage areas. West of Loch Eriboll the streams are shorter and characterised by straight southeast-northwest sections which corresponds to the general direction of Quaternary ice movements. The origins of many of the valleys, however, are a more difficult problem involving an appreciation of drainage patterns evolving on long-vanished surfaces.

In Quaternary times the area was covered by an ice cap with a conjectured ice-shed east of the present watershed and running in a generally north-south direction. Several series of ice movements traversed the area but the *general* direction of the flow is as shown in Figure 1b although it must be stressed that there has been little detailed research on the glaciations of Sutherland. As important were the deglaciation phases when great masses of sand and gravel were carried down the pre-existing valleys or across the plateaux in relatively short-lived meltwater channels. Much of this material like the glacial till of the earlier stage would be carried far offshore to the west and north. This seems to be particularly true of the west and northwest coasts where till and outwash deposits are generally confined to pockets in the valleys or on the lower sides

Area: STOER **NG Ref: NG 039283** **Date: 2/7/69** **Tide: High**

<table>
<tr><td>Exposure index % (wind)</td><td>Exposure (sea)</td><td>Materials</td><td>Slopes</td></tr>
<tr><td>N 12
NW 9
W 0
SW 0
S 4
SE 6 shingle
E 8 ridge
NE 11
N 12

from H.W.M. mid point of sand beach.</td><td>Bearings to islands, reefs, etc.

N. headland 297°

S. headland 225°

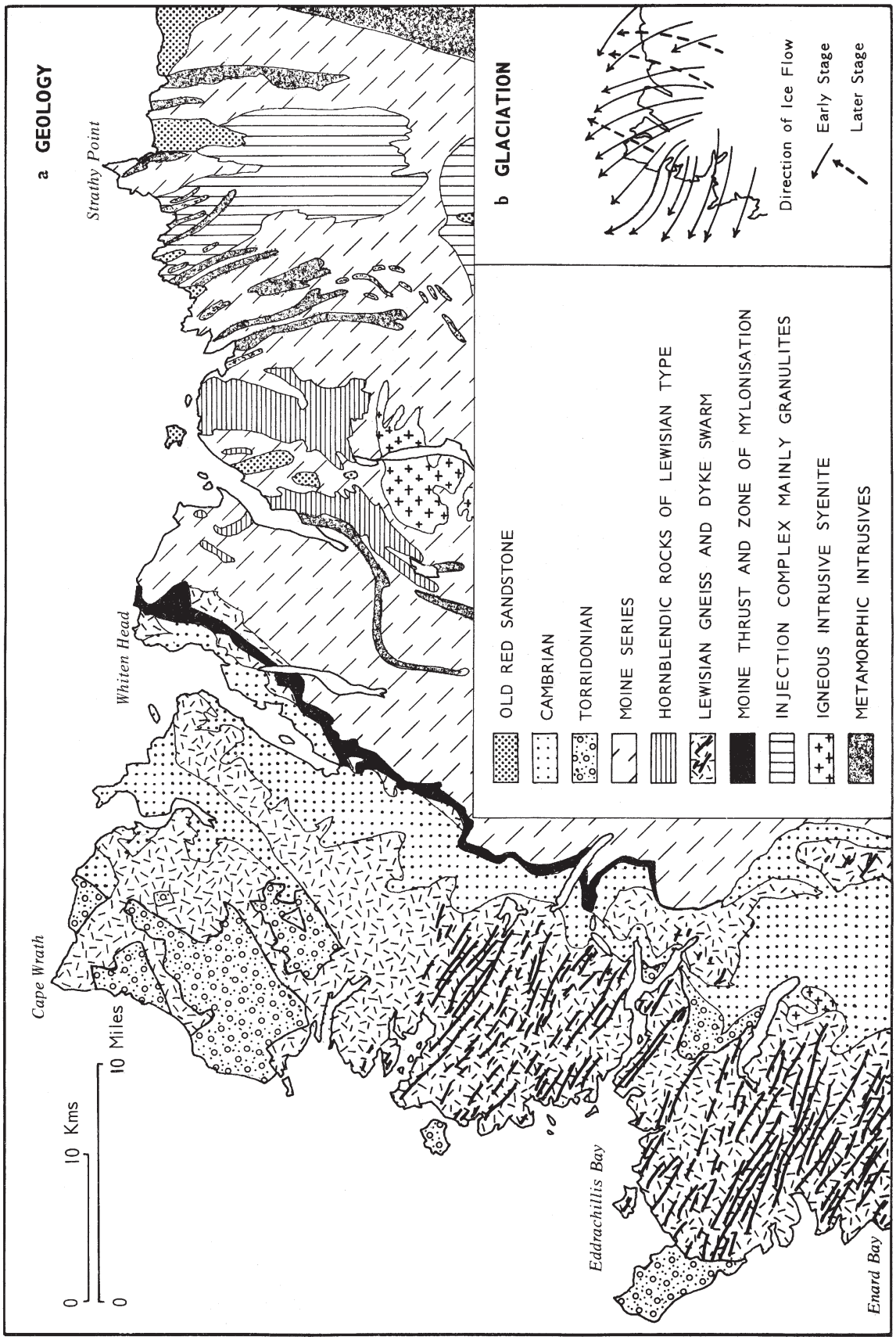
Reef 233-225°

Notes (always to H.W.M.) °M</td><td>Fine reddish sand, light coloured, high shell content.
Sample reference and location: S_1 – south facing edge. S_2 – dune pasture.
Probable source(s): Partly from local Torridonian rock. Shingle ridge mainly Torridonian rock with small amount of mixed metamorphics.</td><td>Beach: upper 6°, ridge of shingle 33°.
Dunes: –
Links: generally 1° to sea.

Degree of dissection (relief): Subdued – rarely more than 3m.</td></tr>
<tr><td rowspan="3"></td><td rowspan="3"></td><td>Offshore ground</td><td>Land Tenure</td></tr>
<tr><td>Sand banks in bay.
Rocky foreshore, seaweed covered.</td><td>Common grazing.</td></tr>
<tr><td>Land use</td></tr>
<tr><td colspan="2"></td><td>Sheep grazing – no arable. No caravans or camping.</td></tr>
<tr><td colspan="2">Special tidal or wave conditions</td><td>General structure</td><td>Vegetation</td></tr>
<tr><td colspan="2">Evidence of spray action on north side of bay.
Strong convergence due to deep abayment.</td><td>Horseshoe depression backed by rugged Torridonian cliffs (fossil and active).</td><td>NO dunes. No maritime grasses. Machair sward contains rich flora but signs of overgrazing by sheep and rabbits.</td></tr>
<tr><td colspan="2">Beach parameters (from 6").S. map</td><td>Thickness</td><td>Estimate of stability (0-5)</td></tr>
<tr><td colspan="2">H.W.M. L.W.M.
as on 6" map</td><td>Some erosion faces up to 1m. deep.
Probably deep in centre. No rock exposures.</td><td>(0 – unstable, eroding by natural and/or biotic agencies).
(5 – very stable, little human interference).</td></tr>
</table>

Physical processes	**Human and Biotic processes**
Most erosion features face S. or S.W. Essentially an infilled depression retained by strong shingle ridge 3-4m high. Also a fossil boulder fan in N. corner at stream outlet. Mature surface of machair now adjusted to normal geomorphic processes. Still infilling towards E. into loch margin – machair also merges southwards into infill coming from further south ie from Clachtoll. Erosion concentrated at relatively high level on flank of S. facing hill mass. Sand blows to over 100ft OD. No dunes, stable beach, strong shingle ridge. Occasional section suggests 5–6 periods of blowing and consolidation. Gentle undulations of machair tend to be transverse to beach, and suggest that they are very old, flattened blowout alignments.	Sheep and rabbit grazing are main biotic factors. Overgrazed and on steeper slopes of N. edge this has led to some erosion and slipping. Sheep rubbings still noticeable. Rabbit population now *less* than formerly. No caravans except E. of main road (which runs *through* machair area) and 3 chalets (well-sited and tidy). One bare track across machair to coastal edge.
Special observations	
Well preserved broch on south cape. Rich machair flora and loch margins have good examples of lacustrine/marsh species.	

Figure 1 Geology and Glaciation



of less exposed hill masses and the overall impression is of erosion and ice-scouring. On the north coast, however, particularly east of the Kyle of Tongue, enormous thicknesses of outwash deposits are found as eskers, kame terraces and outwash deltas in the valleys and low ground (and often superimposed on earlier till deposits). Such thicknesses of unconsolidated deposits are not confined to the valleys, however, and great cliffs of till and outwash become increasingly common east of Torrisdale Bay and it is to these sources that we must look for the materials which form the beach and dune areas.

Thus the west and northwest coastlines are fundamentally different from the northern littoral: in the north-west inlets are steep-sided glacially deepened trenches, glacial and fluvio-glacial deposits are rare and, with few exceptions, the steeper landward and offshore gradients have given little opportunity for depositional coastal environments to exist. In the north the discordant junction of much more varied rock types against the sea has permitted great inlets to press far inland and given greater variety of the scenery; depositional facies of ice and meltwater are represented on the coastal platforms and cliffs and in the valleys. Nevertheless, this is a rugged, steep modified coastline and it is only where the straths or where the drowned inlet, such as Loch Eriboll in the Kyle of Tongue, open into the sea that configurations suitable for growth of beach, dune and machair are permitted.

Sea Level Change

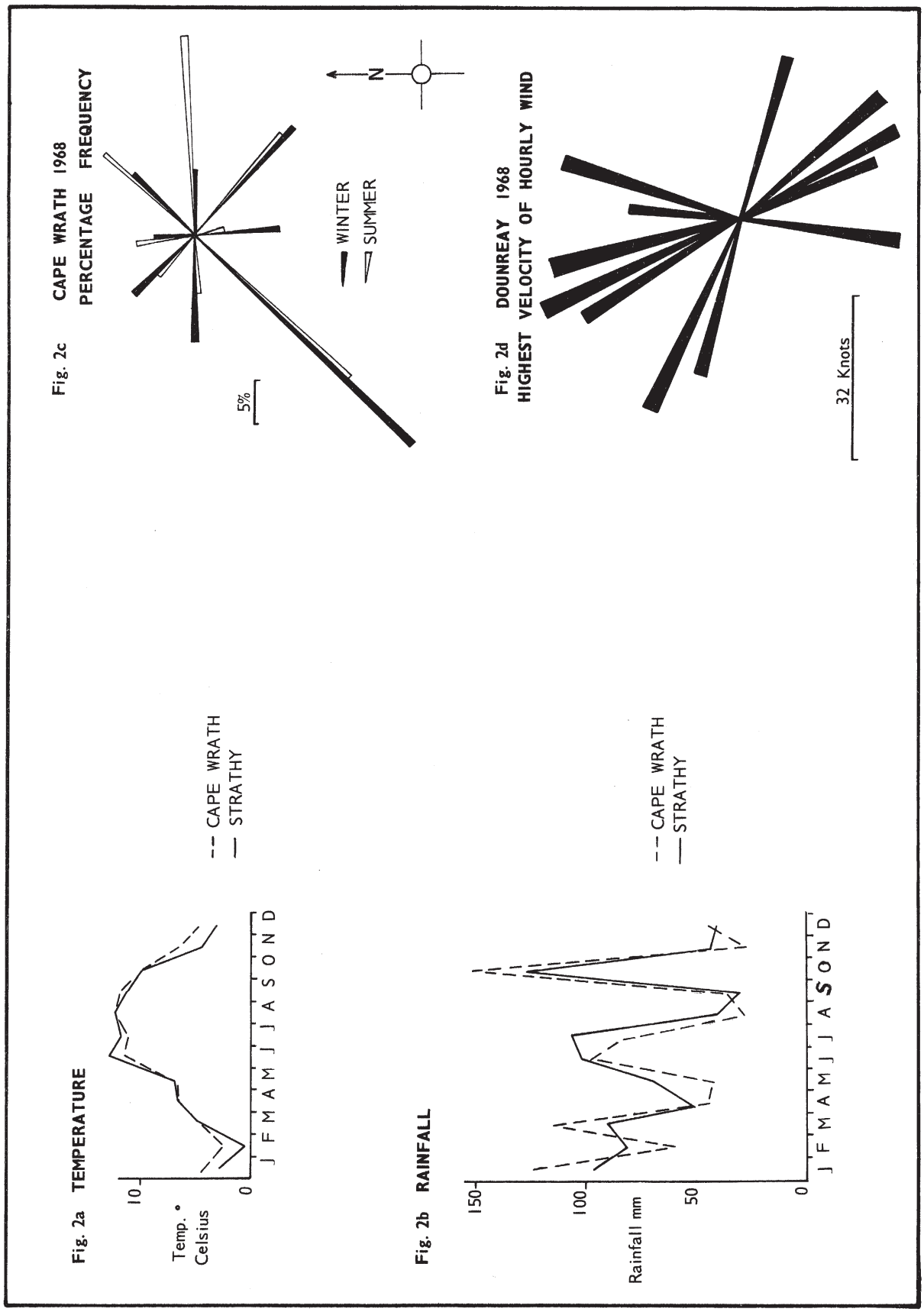
No account of the Scottish coastline can begin without some reference to sea level change since Late- and Post-glacial times. The combined effect of eustatic rise and isostatic rise and fall have given rise to a complex series of raised and submarine features in the landscape. Many of these raised shoreline features although areally small, are of considerable local importance as for example where they provide strips of level arable land or sites for township development. Indirectly the changing sea level has altered the erosive and depositional regimes of all the rivers in Sutherland. The clearest expression of this is to be found in the multiple terrace levels of the lower river courses: terraces which are now used for agriculture and communication purposes or as in Strath Halladale as a ready source of sand and gravel for constructional use.

There is general acceptance that both the west and north coasts of Sutherland should lie within the zone affected by Late- and Post-glacial seas. Unambiguous evidence of higher shorelines was not found on the west coast but ample evidence of several higher seas was found east of Loch Eriboll. Two reasons may be advanced for the lack of clear evidence on the west coast:

(1) the generally rocky configuration and lack of suitable physiographic situations where raised shoreline forms could be created *and* subsequently preserved;
(2) the probability that ice still reached what is now the west coast at relatively later stages of the glacial period.

On the north coast and especially in the Kyle of Tongue-Torrisdale Bay area abundant evidence is found in the form of old cliff lines cut in unconsolidated material, low depositional features of soil and shingle and in sites of outwash features adjusted to higher base levels. (On the basis of levelling so far completed there appears to be higher shorelines at approximately 14–16, 21–27, 45–52ft but considerably more research must be completed before these levels can be accepted. In addition there is some evidence that some of these shorelines may become higher eastwards.) Abandoned rock cliffs and several levels of marine

Figure 2 Climatic Data



planation cutting across varying lithologies are also found along the north coast and to a lesser extent on the west coast, but it is highly probable that such rock-cut features could not have been formed by the relatively short-lived Late- and Post-glacial seas but developed much earlier as for example in pre-Glacial times.

Thus the greatest asset of the Sutherland coastline – its diversity – has its origin in the variety of its rock types in structures which have been differentially modified and affected in the past by complex patterns of ice and meltwater movements. Varying levels of the sea have also added to the variety of landforms produced and even today the evolution is far from equal not only as a result of local climatic and marine differences but by the intensity and type of land use.

The Climatic Background

Since the Ice Age the climate has passed through cycles of weather ranging from Arctic through Periglacial to Humid Atlantic conditions and has created the range of conditions under which the various types of landform development have proceeded. The climate of today also controls the thermal and hydrological background to the present slow process of landscape evolution. Indirectly it affects the land use which is now a highly pertinent aspect of the problem. For any coastal study, however, the understanding of wind direction is the most important climatic element. Wind vectors control wave action which in turn determines the nature and extent of both depositional and erosive marine activity.

The general climatic differences between west and north are apparent from the statistical information summarised in Figures 2a, b, c and d. The source of this information is the Monthly Weather Report for 1968 and the stations used are the only ones available for the area and are not as representative as one would like. Nor is the information in a form which is readily of use since, as for example with wind directions and speeds, these are given separately and to overcome this the pattern of strongest gusts its shown in Figure 2d but these are for Dounreay – Cape Wrath does not make a return of these wind patterns. Nevertheless the general wind pattern of Figure 2c shows that winds blow most frequently from the southwest quarter in both summer and winter. The increasing frequency of easterly winds is a feature of the summer pattern. It is clear that no single direction can control the directions of wave and wind action on the coastline. This has two important repercussions – (1) beaches and other constructive coastal forms will be highly dynamic and changeable features such as berms, sand banks, runnels and drainage channels will shift in response to short-term weather cycles; (2) erosion of sand dunes and machair can proceed from any direction (although local topographical detail may be a complicating factor). With such a variable pattern of winds local factors such as fetch, exposure and topographical detail become relatively more important in the process of predicting coastal evolution. In the longer term, however, if 1968 was a typical year and if one accepts the hypothesis that it is the extreme condition that is more important than the average Figure 2d indicates a concentration of high wind velocity into two sectors N.W.–N.N.E. and S.E–S.S.W. along the north coast and these two directions show some correlation with the morphological features and directions of sand movements discussed in the subsequent regional descriptions. The climatic information should also be considered in conjunction with the exposure diagrams of Figures 5a and b.

Although wind strengths cannot be correlated with directions the following table (1) indicates how high latitude and exposure combine to produce a general prevalence of strong winds throughout the year. The coastline of Sutherland can therefore be described as a zone receiving a high energy input for both marine and aeolian processes.

Table 1 Winds – Cape Wrath

Winter – January, February, March, October, November, December.
Summer – April, May, June, July, August, September.

Number of wind readings at fixed times in strength categories (sum of 4 daily readings)		
Knots	**Winter**	**Summer**
34+	46 (6.3%)	8 (1.0%)
22-33	148 (20.2%)	67 (9.2%)
11-21	248 (33.9%)	231 (31.6%)
1-10	260 (35.5%)	357 (48.8%)
0	30 (4.1%)	69 (9.4%)

Number of wind readings at fixed times from given directions (sum of 4 daily readings)		
	Winter	**Summer**
North	32 (4.6%)	42 (6.3%)
Northeast	59 (8.4%)	95 (14.1%)
East	57 (8.1%)	156 (23.6%)
Southeast	121 (17.2%)	101 (15.3%)
South	74 (10.5%)	26 (3.9%)
Southwest	209 (29.8%)	154 (23.3%)
West	84 (12.0%)	45 (6.8%)
Northwest	66 (9.4%)	44 (6.7%)

Marine Conditions

Three aspects of inshore information are relevant to this study:

(1) The tidal range which is the means of distributing the energy of the waves over a greater or lesser zone;
(2) The configuration of the submarine contours, which are an extension of reefs, islands and headlands in so far as it affects the convergence and divergence of wave fronts. Offshore banks and deeps may be revealed which affect the movement of materials onto the coastline;
(3) The existence and nature of unconsolidated deposits on the continental shelf.

The above information is shown on Figure 3 which has been compiled from current Admiralty Charts. Several points are worthy of special notice, viz:

(1) The abundance of various grades of sand (including shells), gravel and stones;
(2) The lack of any recognisable pattern in these deposits apart from the general tendency for the proportion of stones and gravel to increase towards the east and form more continuous areas;

The above points are sufficient to suggest strongly that this shelf area is liberally covered by great, heterogeneous deposits derived from ice sheets, glaciers and outwash.

(3) That there is no appreciable difference between the north and west coasts apart from the frequency of rock exposures close to the coastline to be greater west of Loch Eriboll and south of Loch Inchard where the inshore ground becomes much more broken and irregular, with numerous reefs, islands and skerries.
(4) That there is no significant correlation between depth of water and nature of bottom materials.
(5) That the submarine contours are generally sub-parallel to the coastline except between Cape Wrath and Loch Inchard, and between Loch Eriboll and the Kyle of Tongue where two "aprons" of ground less than 30 fathoms extend westward and northward respectively. Whether or not there are great depositional forms or debris-covered rock platforms is impossible to conclude.
(6) That Loch Eriboll is quite different from the Kyle of Tongue and Durness in having a constructed deep of over 180 feet at the constriction of White Head.

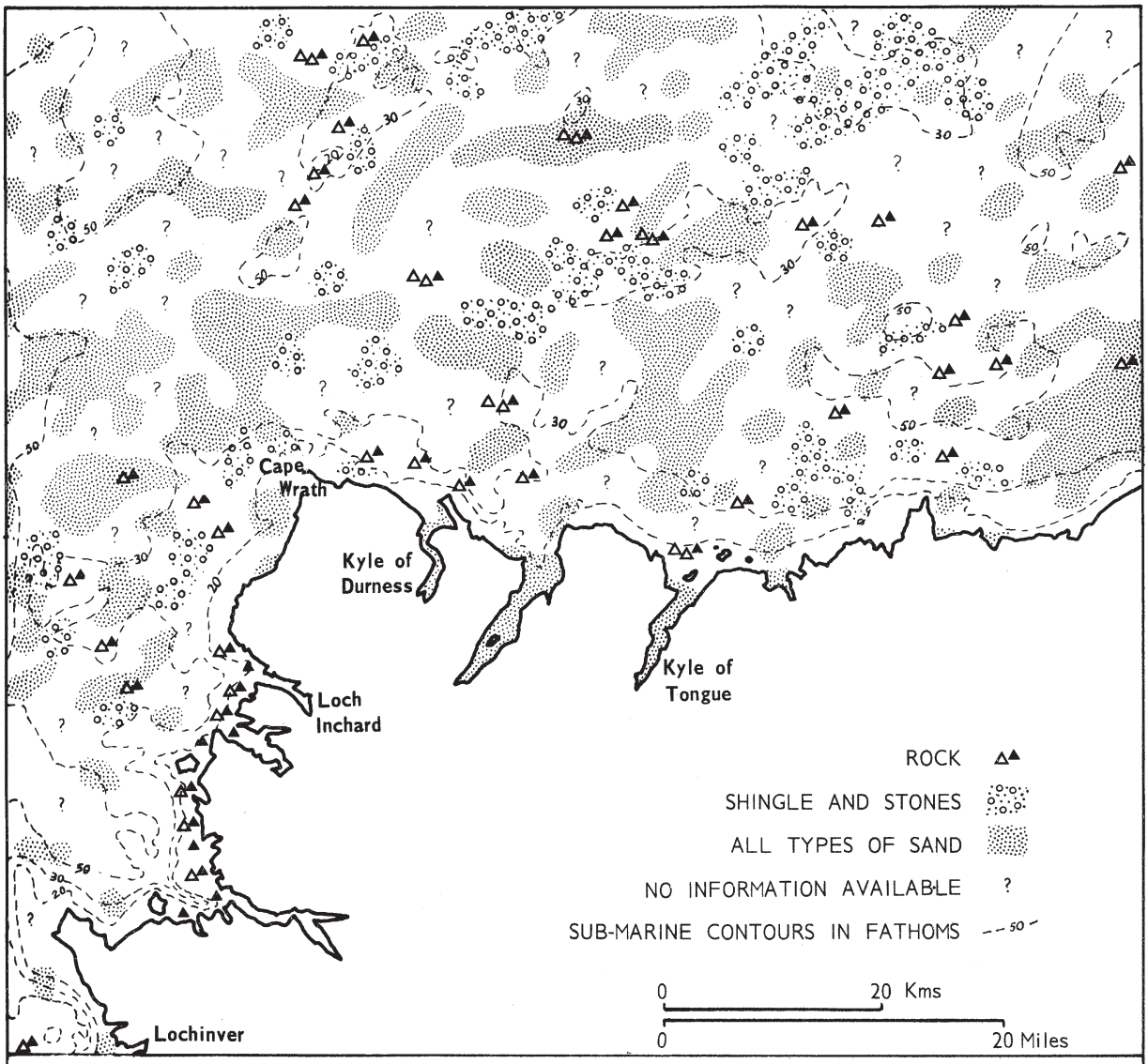
The information given on offshore deposits which is admittedly discontinuous in distribution since only a fraction of the soundings taken by the Admiralty give any information of the nature of the bottom can be summarised further as in the following table.

Table 2

Type of bottom	**Number of soundings in area shown in Figure 4**	
Rock	38	12.5%
Hard Ground	7	2.3%
Various Sands	114	37.5%
Shell Sands	80	26.4%
Stones and Gravel	61	20.1%
Mud	4	1.2%
	304	100.0%

Thus the abundance of "shell sand beaches" and the consequent lime-rich nature of the dune and machair pastures is clearly explained by the above. The proportion of shell sand to siliceous sand tends to increase between Cape Wrath and Strathy Point and towards the shallower ground.

Figure 3 Offshore and Tidal Data



TIDAL INFORMATION	RANGE	
	Mean Spring	Mean Neap
KYLE OF TONGUE	14.6	–
KYLE OF DURNESS	12.6	5.4
CAPE WRATH	14.6	–
LOCH INCHARD	12.9	5.6
LOCHINVER	13.5	5.7

4. Background Human Factors

Down through the ages the coastal zone of north and west Sutherland has proved more attractive to settlement than has the desolate moorland interior of the county. In the last two hundred years, this relative attractiveness has grown, and continues to grow as tourism develops on the well endowed resources of mountain and coastal scenery. Although much of the coast of the north and west of the county is bleak, inhospitable and inaccessible, at intervals patches of blown sand occur. These sand areas are originally marine in nature, or originate in glacial and fluvial-glacial deposits reworked by marine action. Invariably these areas are of higher potential for agriculture than the surrounding rocky knolls or peat filled hollows, whether the use be for cultivation, or as is more frequently the case, for grazing. The soils formed on the sands are usually freely drained, so that waterlogging is no problem; they are light and easily worked and warm up quickly in spring, and above all they do not suffer from the high acidity of the surrounding areas. Thus it is not surprising that the blown sand areas have long been valued as farming land.

During the early decades of the nineteenth century, the relative importance of the coastal zone as a settlement zone was reinforced by the displacement of a considerable agricultural population from the inland straths of the county onto the coast with the introduction of commercial sheep farming into the Highlands. These Clearances were frequently accompanied in Sutherland by resettlement schemes in coastal areas where it was hoped that commercial fisheries would be developed. The resettlement townships were not always laid out in close proximity to sandy beaches or to areas of blown sand, although this frequently happened, but many of the coastal settlements surviving to this day date back to this period, as indeed do many of the problems facing them. The croft units laid out at the time of resettlement were far too small to provide an adequate source of livelihood, and with the failure of fisheries to develop, in itself very largely a reflection of strong environmental controls, a legacy of rural depression and depopulation has been left. In Assynt, on the other hand, paradoxically the growth of fisheries during the nineteenth century has left a similar legacy. The attraction of fishing encouraged the continued subdivision of holdings to maximise the available sea-going population, so that the croft became more and more of a home and less and less an agricultural unit. When the local fishing industry began to contract and decline as competition became more severe from the larger, better located fishing centres, a period of rural decline set in. This familiar period of land hunger and rural poverty in Highland Scotland culminated with the Crofters Commission and the subsequent Crofters Holding Act of 1886 which has gone so far towards fossilising the rural landscape of Atlantic Scotland.

Outside the crofting areas, the two predominant forms of land use are the sheep farms and the deer forest. In the case of the former, again we must look to the beginning of the nineteenth century for its appearance on the landscape. However, in a purely coastal context, these sheep farms are of much less significance than are the crofts, because initially it was the inland valleys that were taken by the commercial farmers and the coastal strip reserved for resettlement schemes. Likewise the deer forests, products of late Victorian times, are mainly inland phenomena rather than coastal ones.

Today, as the inset map on the frontispiece indicates, most of the west and north of Sutherland is occupied by crofting townships and their common grazings. Except for small areas between Cape Wrath and the Kyle of Durness, to the east of the Kyle of Durness, and to the east of Loch Eriboll, most of the coast is under crofting tenure. In addition to the croft land itself, which cannot be resumed out of crofting use except through the Scottish Land Court, there exists the common grazings with their own set of regulations for use and

change of use. A small proportion of the croft land may be under cultivation, but an increasing proportion is given over to grass as the old subsistence economy wanes. The common grazing, on the other hand, as the name implies, is solely given over to grazing. The common grazing area very frequently occupied most of the machair, and so many beach head areas of today constitute common grazings, with all the legislative difficulties this implies for the development of caravan sites and other tourist facilities. While the need for diversification in the crofting areas, and for supplementary income beyond that received for stock and from subsidies, is readily admitted, it is not always easy to obtain full agreement in a crofting township on any matter concerning the possible use or change of use of a grazing.

Grazing is controlled by grazing committees elected in the townships, who are supposed to enforce the soumings and prevent overgrazing and misuse. The concept of overgrazing is a difficult one, although it is clear that such grazing will have a detrimental effect not only on the vegetation and so carrying capacity of a given piece of ground, but also more seriously may give rise to soil erosion and run-down of the land potential through failure of the binding and protective functions of the vegetation. It was not possible to assess the permissible grazing potentials in the short period of time available for fieldwork, although the opinion was occasionally expressed that overgrazing was being practised in certain commons. It was certainly clear however, that on many areas there were far too many rabbits on the ground, and the detrimental effect of this was obvious.

The size of the common grazings, the proportion of them occurring on the machair, where it exists, and the regulations governing their use show great variations from place to place. At the simplest, each township has its own common grazing, in which each crofter has an equal share, the number of stock he is allowed to keep often being based on so many animals per £1 1886 rent. On the other hand, some commons are shared between two or more townships, and in some grazings part of the ground may be common between certain crofts, and part common between the whole township. Certainly the regulations frequently seem rather complicated, the more so because of their relevance to 1886 conditions rather than to the conditions of today.

On the sheep farms, such as that at Balnakeil, the tenurial system is much more straightforward. Although by far the greater percentage of the land on the farm is unfenced rough grazing, there is usually also a proportion of land under arable crops, mainly growing winter fodder, and improved grass. Where this is the case, the improved land frequently fronts onto the beach, so that access from road to beach may become more difficult. The situation as regards *de jure* access in Scotland is notoriously complicated, but on few of the beaches investigated in Sutherland did *de facto* access come up against serious difficulties.

The present day settlement and communications pattern is essentially a coastal one, with few habitations or roads away from the coast. Tourism, in terms of direction of tourist movement, and availability of accommodation, is rigidly controlled by both these factors. The main arteries of flow are the north and west coast roads, with comparatively little inland penetration, while the existing nucleated or semi-nucleated settlements have developed as the main centres of hotel and bed and breakfast accommodation. Likewise, the recreational use of beaches is rigidly controlled by the existing road pattern, especially by the north coast and west coast roads. On the north coast, the main road runs parallel to the coast although some distance back from it in places. The sea is usually in sight, although not always the shore. Occasionally, for example just to the east of Durness and again at Coldbackie, the beaches are close to but well below the road. Elsewhere, although the beach may be visible from the road, access is not easy or direct either for

pedestrians or for vehicles, so that in such places tourist use is usually slight. Where the road runs close to but above the beach, the pattern of use is usually a short visit during a break in the drive along the coast; camping or caravanning is not usual except at Durness where access from the road to the clifftop overlooking the beach is very easy. On the west coast, the main road runs much further inland than in the north, except for a short stretch near Scourie. This means that "passing" visits to the shore are much rarer than if the road closely followed the coastline. Furthermore, the most attractive beaches are well off the main road, being reached by a rather tortuous but well used secondary road in the case of the Clachtoll group of beaches, and by a dead-end road in the case of the Oldshore More group. Thus prior knowledge of the existence of the beach is required before a visit is made. However, especially in the case of the Clachtoll group, vehicular access onto the machair is possible. Thus the ease of access, combined with the inherent attractiveness of the beach, have meant that caravanning and camping have become popular. This means that on the west coast the pattern of tourism development has tended to be a residential one, with people actually living on the environs of the beach, while on the north coast, with the exception of Sango Bay and to a very minor extent Balnakeil Bay, the pattern is rather one of brief visits and is not primarily residential. This contrast is of primary importance in the context of conservation of the beach resources, since experience shows that it is not the occasional pedestrian visitor who is likely to damage the beach area but the one with the car or caravan who drives over it.

The most seriously damaged beaches are those where caravanning is popular, at Achmelvich and Clachtoll. For a number of years these beaches have been the subject of controversy, with the local crofters wishing to exploit them to the full as caravan sites, and the county council attempting to control their use by making planning permission conditional. The controversy culminated in public inquiries about both Clachtoll and Achmelvich, when the crofters appealed against the conditions imposed in granting planning permission, but in both inquiries the crofters lost their case. (Northern Times, 30th March, 1962, and 15th June, 1962 respectively.) Despite these results, however, the situation has never been satisfactorily resolved, and the problem has dragged on down through the years. The problem appears to be primarily one of over-exploitation of resources. The machair areas are valuable agricultural resources and have been so for centuries, but in recent years the natural balance which formerly operated seems to have been tilted, and in some areas erosion is proceeding inexorably. This is not to claim that erosion is brought about solely by tourist activities; indeed on the contrary there is stratigraphical evidence that sand blowing has occurred in the past. Indeed erosion, especially of dunes, is a natural process in the evolution of mature machair topography. The real problem is the rate of the erosion, the distribution between dune and machair areas, and the type and intensity of the erosion. The critical area is the machair itself rather than the dunes, for the mature swards and soils of which may have taken centuries to evolve in contrast to the rapidly changing dunes, but which may be destroyed in a matter of years or decades following the introduction of a new factor which may upset the natural balance which previously existed. It will be shown below that in some areas tourist use, especially through caravanning, has proved to be such a factor, and that the natural ecological balance has been upset, with consequent unfortunate repercussions on the resource.

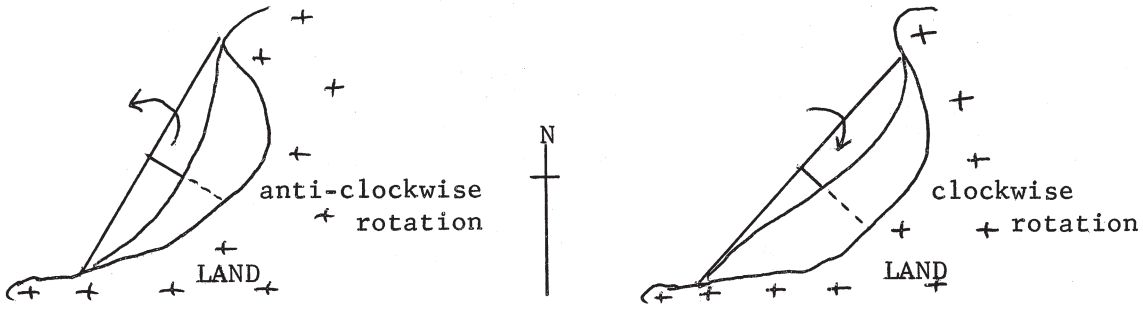
5. Regional Description of the Principal Beach, Dune and Machair Areas

The subsequent chapters describe and assess the beach, dune and machair areas of north and west Sutherland. Each sub-chapter should be read in conjunction with the relevant geomorphological map. There is also additional information in the form of maps, diagrams and tables about vegetation, exposure, beach stability parameters and textural analyses.

Distribution maps of generalised vegetation types are given in Figure 6, and a composite "type-profile" is shown in Figure 4.

Exposure index diagrams were compiled from field measurements using a variation on a standard forestry technique, viz. to measure the slope to the highest skyline in the eight compass directions. These exposure diagrams are given in Figures 5a and b, and, in general, the larger the sector the greater the protection from that direction, and the larger the diagram the greater the all round protection of the beach.

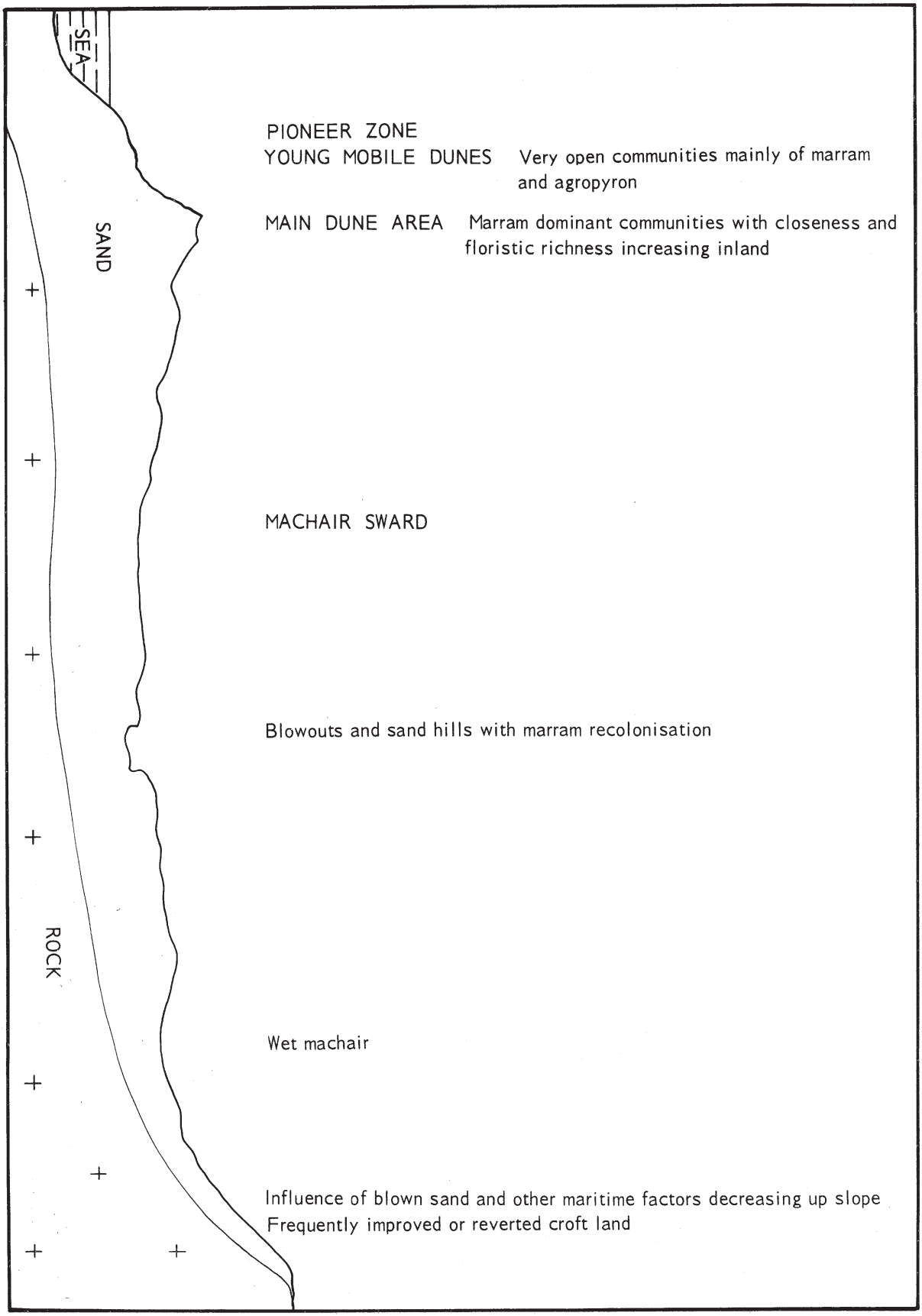
Beach stability parameters consist of chord directions, ie the line joining the points where the low water marks of the beach meet the rock of the supporting headland and converge with high water mark. The orientation of this chord gives the alignment of the beach which, if the beach is in equilibrium, is at right angles to the most important direction of wave action. From the mid point of the chord (c) a perpendicular (p) is dropped to low water mark. The chord (c) divided by the perpendicular (p) gives the Index of Curvature ($^{c}/_{p}$). Experience elsewhere in the world has shown that the closer the Index of Curvature approaches unity the more stable the beach. A comparison of beach areas on either side of the perpendicular also reveals the direction in which the beach is tending to accrete or rotate.



Sand samples were also collected from beach, dune and machair areas. The samples were dried and sieved and the quantities passing through each British Standard sieve was weighed, the cumulative percentage calculated and the results plotted on semi-logarithm graph paper as shown in the sample curve, Figure 7. From this graph the median diameter of sand and the quartile values can be abstracted. The median diameter or average grain diameter is related to the strength of the current that moved the sediment to the site of deposition. The difference between the 25% and 75% quartile values gives a measure of the spread of the distribution on either side of the median and as an index of the range of conditions and degree of turbulence in the transporting agent: the wider the spread the greater the range of conditions. The carbonate content, equivalent to the shell sand content of each sand sample was also defined by the carbon dioxide method.

All these results are tabulated in each regional description and consolidated tables are given in Appendices.

Figure 4 Model Vegetation Profile



5.1 Achmelvich

Morphology (Figure 8.1), Vegetation (Figure 6.1), Exposure (Figure 5a), Photographs 1 and 2.

Achmelvich sands occupy a small bay about four and a half miles north of Lochinver. The beach is a small one, only about 130 yards in length with an inter-tidal zone of about 60 yards, and a wide upper beach between high water mark and the front of the machair. The general trend of the coastline is north-northwest, but this general trend is broken by a number of large and small indentations. Achmelvich Bay occurs in one of the indentations, and is bounded on its south side by the headland of An Fharaid which separates it from Loch Roe. The bay itself is about one mile long, although the sands only occupy a small part of it, and is markedly assymetrical, with a gently curving northern portion and a protruding south headland which acts as a sort of groyne minimising movement of material outwith the bay. The sands lie in a very small embayment on the south limb of the larger bay, and face the northwest. They occupy an irregular depression between headlands of Lewisian gneiss. This depression seems to have been excavated along the northwest trending dyke in the Lewisian gneiss basement. Although in the regional context there is a graining of the gneiss ridges in a northwest direction, such a graining is not apparent in the local scale, and there is no preferential orientation of the ridges. The gneiss is ice-scoured and is almost completely devoid of a superficial weathered layer or glacial till. Offshore the submarine contours are parallel to the coastline in the bay, but on the south side of the bay the south headland cuts the five fathom contour immediately off the sands, so that deep water approaches quite close in. The inner parts of Achmelvich Bay are sandy, although off An Fharaid headland the ground its rocky and weedy.

Exposure, as Figure 5 indicates, is fairly strong, especially to the northwest quarter. The "bay within bay" position affords some protection from waves, but there is little protection from the wind.

Despite the relatively strong exposure, marine erosion is not much apparent. Little cliffing has occurred, since the nature of the Lewisian gneiss, in particular its jointing pattern, is not readily conducive to cliff formation. Little sediment would be derived from local cliff erosion, and shingle and cobbles are almost completely lacking from the beach area. The front edge of the machair has retreated so far under wind erosion that it is difficult to say whether or not undercutting from the waves has taken place. However, the $^{c}/_{p}$ ratio is rather high at 11.25, suggesting that the stability of the beach in terms of marine processes is not very high. Also there appears to be a slight tendency for the beach to rotate in a clockwise direction.

Not only is there little sediment supply from the erosion of nearby cliffs, but supply of material from fluvial sources is almost totally lacking. The few very minor streams which do occur mostly flow through marshy areas which will act as sediment traps before entering the sea, while a slightly more sizeable stream which enters the sea at a small beach to the north of the main beach via a gorge, flows out of a small loch and also will carry little sediment. In the absence of other possible sources of material, it must be assumed that most of the material of the beach and machair is derived from glacial deposits offshore, together with shells. These deposits have been reworked by the sea, probably at different levels, and swept into the narrow embayment to form a beach. (For table of sand parameters see Appendix 2.) The beach in turn provides material which will blow inland, and in this respect it is significant that there is a wide stretch of upper beach above high water mark over which the wind can work. Windblown sand does not accumulate in a frontal dune ridge, as is normal, but instead blows directly inland onto the machair. A considerable thickness of machair seems to fill the depression in the gneiss, and it thins out against the margins of the depression

where rock comes close to the surface. The surface of the machair is characterised by a number of old and young blowouts and accumulation forms. Even where the machair is fairly thick, on the floor of the depression, it is not flat but gently undulating, with long, broad swells running in an east-west direction. The main factor controlling the orientation of these old erosional and depositional forms is the configuration of the ground around the western headland. In particular, a corridor separating An Fharaid Beag from An Fharaid Mhòr is of great importance in funnelling and focussing winds from the southwest quarter onto the machair. At the point where this corridor opens out, a large although not very deep blowout exists, but it is now healed and fully vegetated. Downwind from this old blowout is found its complementary accumulation form, a gentle east-west trending swell immediately to the south of the road. North of the road, and possibly partly fed from the same source, is another long ridge, slightly curved in plan, which leads almost to the old school. It would seem, however, that the dominant direction of winds likely to damage the deep machair has altered. The influence of winds funnelled through the corridor seems to have waned, while the influence of winds coming from a more northwesterly quarter, over the beach itself, has increased. Some blowouts have occurred on the machair front, but the more spectacular ones run parallel to and between the ridge leading almost to the school and the gneiss walls of the margin of the depression. Here a long, deep blowout has developed, bifurcating at its windward end. Nearer the front of the machair, although the actual front edge is undercut and crenulated, linear blowouts seem to be less common than more circular ones. Blown sand has spread up the flanks of margins of the depression, especially on the north side of the floor of the depression. Here there is a veneer of blown sand about 3ft deep. This veneer is very broken by a large number of blowouts, and is also affected by slow mass movements of which soil creep is the most important. The pattern of blowouts its more complex than that on the depression floor, as the number of variable factors influencing erosion are greater. Firstly, the thickness of sand varies, generally decreasing in thickness with height above the depression floor, and different types of blowouts seem to occur on different depths of sand. Secondly the configuration of the ground and the micro-relief of the gneiss surfaces seem to exert an important influence. Thirdly, and perhaps most importantly, the orientation and macro-relief vary and exert a very strong control on blowout formation. The northern margin of the depression is in the form of two gneiss ridges orientated at an angle of about 45° to each other, one being parallel to the shore, and coming together in a low col. This col and the apron leading up to it contain the deepest and most eroded sand, since winds, especially those coming through the corridor to the southwest of the sands, are funnelled through a narrow opening. Turbulence of the air will be strong subsequent to previous funnelling and spreading out of the winds, and the erosive and transporting power will be considerable. Two long, fairly deep blowouts have formed along the break of slope between the deep and the thin machair, and these blowouts have converged at their downwind ends. Part of one of the blowouts follows the line of a track along the margin of the machair, and the initiation of the blowout may well be connected with the track. In places deflation has occurred right down to bedrock surface, which acts as an effective base level. In addition to these large convergent blowouts, other smaller ones occur. One type is similar and parallel to this first type, running in a northeast-southwest direction just above the larger blowout along the base of the ridge. This type, however, is lacking along the north-south running ridge since its orientation with respect to eroding winds is different. Smaller, crescentic blowouts, with the concave eroding face pointing upwind, exist particularly on part of the ridge on the northeast of the beach. Some of these crescentic blowouts appear to develop into the more linear type, while yet another, but comparatively rare type, are linear but face the southeast rather than the southwest.

This diversity of blowout types is a reflection of prevailing wind conditions. While local effects are very important, that the prevailing direction is from the southwest is illustrated by the accumulation of sand on the

northeast portion of the depression margin rather that on the west or north facing margins which are very largely sand free.

The vegetation pattern differs from the typical sequences illustrated in Figure 4 in the absence of a zone of marram clad dunes on which active colonisation proceeds. While pioneer species are present in some of the blowouts, a continuous early fixed stage zone of vegetation is completely lacking. Under such conditions, the mature machair sward which occurs inland could not have developed. Thus it would seem that a dune-marram zone was at one time present but has subsequently been removed by erosion. The removal of this dune zone may be associated with decreases in the rate of supply of material to the beach. If the offshore ground has largely been swept clear of transportable material above wave base, the rate of supply of sand to the beach would fall off. The decrease could be to such an extent that natural erosional processes in operation on the dune area would exceed the accretion of sand, with the result that the whole dune zone would eventually be removed. Not only might the entire dune fringe be removed, but erosion could spread inland into the machair front. This has certainly occurred and indeed is still occurring at the present day.

The machair sward is a typical one, although in places the instability is reflected in small patches of bare sand between the individual plants comprising the sward. On its south side the dry machair merges into much wetter machair and eventually into freshwater marsh, while to the north and east, it grades into moorland communities unaffected by blown sand. The headlands and the gneiss ridge to the north of the beach are influenced strongly by salt spray and the plant communities are correspondingly modified.

Most of the machair area forms part of the Achmelvich common grazing. However, the situation its complicated by the fact that part of the grazing is common between certain crofts and part is common to the whole township. In summer little grazing is carried on since most of the machair is given over to caravanning, and there is a licensed site for 36 caravans. The attractiveness of Achmelvich for caravanning is readily appreciated. Vehicular access is possible right on to the machair area backing the beach, although the road from Lochinver to Achmelvich is narrow and steeply graded in parts. The sands and bay are scenically attractive, and access to the beach is very easy. Thus over the years quite a large scale development of caravanning has taken place, and during the period of investigation in early July there were no fewer than 65 caravans on the ground. There is no restriction on the driving of cars across the machair sward and not surprisingly vehicle tracks have appeared with the vegetation carpet completely destroyed along the wheel marks. Fortunately most of the tracks run in a roughly north-south direction, transverse to the dominant wind direction, although, they are parallel towards the northeast of the machair where serious blowout damage has occurred. In places, however, blowouts have eaten into part of the tracked machair, especially at the front edge so that new routes and multiple tracks have appeared. More dangerous in places than straight vehicle tracks are turning places. Under certain moisture conditions it seems that small-radius curved tracks are more liable to cause vegetation damage and result in erosion than are more utilised straight tracks, and there seems to be an association between small circular or crescentic blowouts and these turning places. While most of the tourist damage its connected with the use of cars, other potential sources do exist. Perhaps the most important of these is the burying of rubbish in the machair. The breaching of the turf carpet and the loosening of the already light, sandy soil can prepare the way for blowouts to be initiated, and even apart from this there is the danger that purely natural blowouts will in time spread and expose dangerous and unsightly spreads of rubbish.

Thus both in terms of natural and tourist processes, Achmelvich must be regarded as one of the beach areas

of great instability. Much damage has already occurred, and there is strong evidence to suggest that the present level of utilisation can only result in accelerating deterioration of the resource. It is suggested that the numerical limit on caravans set under licensing conditions should be rigorously enforced, and it is further recommended that vehicular movements on the machair should be restricted to the minimum, although it is recognised that this would be difficult to enforce. At present the valuable resource of the beach and machair area is rapidly deteriorating, and it is to be hoped that it will be appreciated that the present level of exploitation cannot be sustained over a long period of time.

Photograph 1 Achmelvich – Main camping and caravan area.

Photograph 2 Alcmelvich – Caravans at edge of beach. Note absence of dunes.

5.2 Clachtoll and Stoer

Morphology (Figure 8.2), Vegetation (Figure 6.2), Exposure (Figure 5a), Photograph 3.

Clachtoll and Stoer are adjacent beach and machair areas facing southwest to the North Minch. The Bay of Stoer contains a very stable beach with a low $^{c}/_{p}$ index of 3.6 and a tendency to a slight clockwise rotation. The beach is almost semi-circular, over 500 yards long and strongly supported by rock headlands composed of Torridonian rocks. The northern headland, at Stae Fada, consists of a narrow band of north-south trending conglomerate with a dip of approximately 20° to the west. In both Clachtoll and Stoer this strong regional dip and north-south strike is of fundamental importance in the subsequent evolution of the area. Clachtoll beach is smaller and slightly less stable with a $^{c}/_{p}$ index of 4.9. The beach is almost as wide between tide marks as it is long – approximately 400 yards in each instance. With low indexes and near perfect half-moon shape both beaches are very stable and fully adjusted to wave action from the southwest quarter. In spite of the slightly different configuration of headlands both beach chords are aligned at 338–158° (time). Clachtoll beach is subdivided into two smaller abayments by a cape of Torridonian sandstone. To the west an enclosed beach of shingle and cobbles represents the seaward limit of an important corridor axis trending south-north. This depression and the metamorphic rock platform to the west is almost unaffected by sand drift and demonstrates the paramount importance of west and southerly winds influenced as they are by the openness of the area to these directions (cf. Figure 5).

Both beaches and machair are composed of reddish shell-rich sand the coarseness of which, 450 microns (Stoer), 388 microns (Clachtoll), supports other evidence that the source is ultimately derived from Torridonian beds.

Inland, both machair areas are confined by encircling masses of Lewisian gneiss which is steepest east of Loch an Aigeil and resemble ancient cliffs. This rim of high ground combines with the whale-back Torridonian ridge of Cnoc Breac which rises to over 100ft O.D. to create a semicircular, and in places, narrow depression curving from Clachtoll beach into a narrow pass at the south end of Loch an Aigeil and opening out again in Stoer machair.

The physiographic evolution of the area is in essence the infilling of this depression from both beaches and in particular from the smaller beach of Clachtoll. The process of machair extension is still continuing with the sedimentation of the west and south ends of Loch an Aigeil.

In Clachtoll steeply dipping Torridonian rock exposures indicate how the dominant north-south alignment of blowout and sand ridge is structurally guided. The severe erosion which characterises the area only serves to emphasise these longitudinal patterns. The erosion cycle has lasted for a long time and although precipitated by misuse appears to be the stage of development that this area can expect since there is now little primary dune development: the transition from machair to beach being achieved via a zone of bare sand above normal high water mark. Dune-like forms exist further north and carry vigorous marram and *agropyron* (if closer to the sea) but these are essentially re-depositional features. Much of the sand has spread onto the south side of Cnoc Breac and onto the sides of the nearby Lewisian slopes to the east: a little has drifted northwest to help fill in the marshy tracts on the platform west of the machair area. Some deflation features are very deep and reveal several buried soil horizons which indicate that there has been four or five cycles of stability and erosion. At the base of some blowouts large Lewisian erratics can be seen

to rest directly on the Torridonian basement although, in general, evidence of depositional glacial action is otherwise lacking. Taken as a unit the machair is concave in shape rising at approximately 5° to a summit at about 45ft O.D. and falling at the same angle down to the marshy, wet machair area bordering Loch an Aigeil.

Stoer machair is in contrast to Clachtoll: it is stable. Erosion is confined to scars and terracettes on the high sand spreads at heights of 50–100ft O.D. on the south facing perimeter of the bay. (Footnote 1) Otherwise the area consists of a flat or gently undulating mature machair plain drained by a ditch from Loch an Aigeil and a small stream coming in from the north which has been deflected from the outlet shown on the 1908 map. The stability of this area is further enhanced by the presence of a wide (20–40ft wide, 10–15ft high) cobble and shingle ridge on its seaward margin. Again there are no dunes. A few small blowout features are found on the machair area but in general Stoer stands in marked contrast to the erosion and mobility of Clachtoll. Whether this reflects differences in land use or not is open to debate, but the area has certainly attained a stage of late geomorphological maturity compared with Clachtoll to the south which may either not have reached this late stage or be proceeding on a second cycle of evolution.

The contrast in land use is also striking; Stoer consists entirely of common grazing although it was formerly a nine-hole golf course some 50 years ago when this area which is part of the Assynt estate was owned by the Duke of Somerset. It is now grazed by sheep and there are no obvious signs of overgrazing. The only undesirable feature consists of a sand track from the main road to the beach. Clachtoll is much more complex. The area up to 200 yards north of high water mark is common pasture for Clachtoll township, but north of this the area is subdivided into narrow east-west running croft units and many of the dividing fences and dykes still exist today. There is now little evidence of any arable agriculture, although MacLagan Garvie in an unpublished paper in the early 1950's stated that one croft "still had land under the plough". Croft houses most of which are still occupied stand on the machair: there are no buildings on Stoer machair. This situation of croftland and common pasture occupying the machair area is relatively unusual but reflects the absence of any suitable sites elsewhere in the surrounding region. Further the main road from Lochinver via Drumbeg to Kylesku passes through the machair depression of Clachtoll and through the middle of Stoer machair. In both townships the road is fenced but access to the machair and beach in both instances is easy by means of tracks. Ease of access and, as important, the ease with which one can "discover" the beach while descending the hill from Stoer village in the north or the equally steep hill on the south side means that both areas are well used by tourists. Beaches, and above all accessible beaches, are at a premium in west Sutherland and the use of these beaches will inevitably increase in proportion to tourist growth.

Footnote 1

The density of erosion scars induced by rabbit damage is frequently found on the thin machair areas adjacent to arable or improved ground, or on the margins of the area where the sand thins out over the contiguous landforms. This phenomenon may be related to richer grazing or the reduced hazard of sand slumping or in some instances, even, the problem of winter flooding. Although the explanation is not fully understood it is an important element in the discussion of machair and dune stability since, as will be demonstrated, in almost all the areas under discussion rabbit damage and over-grazing is probably the greatest factor of biotic disruption in these beach, dune and machair environments.

In early July there were few caravans at Clachtoll but most crofts take visitors. Three well-sited chalets are found at Stoer on the north shore of Loch an Aigeil. The scenic attraction of the area in general, which also includes the fine sandstone stack of A'Chlach Thuill and the unfrequented "pocket-beach" to the east of this headland, is supplemented by interesting archaeological sites and for the naturalist a rich machair and marsh flora. For all these reasons the biotic disruption of the area has been of concern for a considerable period. (Footnote 2). In 1954 the alleged danger was so real that Sutherland County Council approved and gave support to a Society of Friends Work Camp at Clachtoll whose sole intention was to stabilise the erosion by building turf walls and erecting other forms of protection. At this time the main agent of disruption was undoubtedly the rabbit, but thanks to myxomatosis this problem is at present greatly reduced. Unfortunately these preservation efforts failed and any similar protection work will undoubtedly fail too, unless backed by sound expertise and large amounts of capital. If the deduction that little sand is coming off the *beach* is correct (and for proof this would require a relatively long period of research) then there is relatively little that can be done to create a protective line of dunes. Given restricted access and a reduction in trampling the blowouts and erosion trenches will reach their own equilibrium in time, but until then the area will undoubtedly take on increasingly the appearance of a sand wilderness and lose its intrinsic attractiveness and value.

Photograph 3 Clachtoll – General view of machair. Note parallelism of erosion features and absence of dunes.

Footnote 2

In a report of a Public Inquiry given in the Northern Times, 30th March, 1962, certain interesting sidelights on the use and stability of Clachtoll were given which included the statements that: (1) caravanning had been going on since the last war; (2) erosion had been going on for 50 years and was partly due to rabbits but mainly to winter gales; (3) Sutherland County Council had used a sand hill near the main road as an open sand quarry; (4) grazing by crofters, stock had never caused any erosion.

5.3 Clashnessie

Morphology (Figure 8.3), Vegetation (Figure 6.3), Exposure (Figure 5a).

Clashnessie is a very small beach about 200 yards across on the northwest corner of Assynt. The beach occupies a narrow inlet at the head of the bay partially enclosed by the Point of Stoer peninsula and Oldany Island. The peninsula is of Torridonian sandstone, but the boundaries of the inner part of the bay are both of Lewisian gneiss. The coast is very low, with high cliffs lacking especially on the south and west sides. A fairly sizeable stream enters the head of the bay, but has been unable to achieve much erosion of the gneiss bedrock, and since it flows out of a complex of lochs, carries little sediment load. Most of the surrounding gneiss is ice-scoured and lacking in a weathered layer or till veneer, although it is likely that some glacial deposits exist out in the bay, which is mainly sandy and whose contours parallel the coastline.

The bayhead position of the beach means that it is fairly sheltered from wind and wave attack, except from due north where a narrow fetch sector is fully exposed. East of north, shelter is afforded by Eilean Chrona and Oldany Island. The line of the bay is continued inland in a depression running through the neck of the Point of Stoer peninsula to Stoer, and there is a tendency for the funnelling of winds through this depression in a northeasterly direction, and these winds appear to be of considerable importance in the evolution of the blown sand forms.

Both the location and the geology and height of the rocky headlands mean that little marine erosion is likely to occur. The western headland is in the form of a low rocky platform, while higher, but still rather inactive cliffs occur on the eastern headland which has a slightly greater exposure to the northwest. In either case, little material can be supplied to the beach from local cliff erosion. Most of the beach sand must be derived from the reworking of glacial deposits offshore, since neither marine nor fluvial erosion is capable of supplying the requisite quantities of fine sand (for table of Sand Parameters, see Appendix 2).

In contrast to the fine material presently comprising the beach, there is evidence that in the past the beach was solely composed of shingle. The erosion of the front of the large sand hill near the axis of the beach has exposed a pavement of shingle a few feet above high water mark, and this shingle beach continues to the west of the stream outlet in the form of a low terrace covered with a veneer of blown sand. This shingle beach now largely buried under later deposits probably represents the work of a higher sea level in the past, when more active erosion was possible on the gneiss cliff to the east and the debris was swept into the inner corner of the bay. The present beach is built up against this sightly raised feature, and sand has blown inland in the form of a linear sand hill resting on the shingle. Although the present beach is fairly stable in terms of marine processes, having a $^{c}/_{p}$ ratio of 6.00 and showing no tendency to re-orientate itself, at some time in the past undercutting of the front edge of the sand hill occurred. According to the evidence of a local crofter, this took place a few years ago during a strong northerly gale which coincided with a very high spring tide. The cutting of a free face in the sand has allowed wind erosion to operate and much of the sand hill and the area to the east of it have been seriously eroded, exposing bare sand and a shingle pavement, neither of which re-vegetate readily. The front edge of the sand hill has retreated some distance, leaving a fence suspended, and is notched by a series of indentations orientated parallel to the crest. The fact that the important eroding winds come from two diametrically opposed directions, from the southwest through the depression and from the northeast, means that there will be a certain amount of reversal of sand movement backwards and forwards along the erosion scars. These winds will have an

abrasive effect and accelerate undermining and eventual collapse of the scar sides. It is likely that such erosion once begun, is likely to continue until most of the sand hill is consumed unless remedial action is taken. In particular, the consumption of the marram clad dune front which once presumably existed has drastically reduced the amounts of marram and *Agropyron* available to recolonise and stabilise eroded surfaces, so that there is little pioneering vegetation available today.

Not only is the sand ridge affected by wind erosion, but it is also undercut on its west side by stream action, and the collapsed sand transported out across the beach. This west side of the ridge, however, is relatively sheltered from the damaging winds, and the banks undercut by the stream have not been greatly enlarged by wind blow.

The main characteristic of the vegetation pattern is the absence of a dune/marram zone. This has probably been removed by erosion, and there is a sharp change from bare sand to mature machair sward on the sand hill. The inland extent of blown sand is short, except along the axis of the valley where the main sand ridge extends about 200 yards. There is a strong maritime influence on the eastern margin of the bay, but here salt spray is a more important factor than is blown sand. Most of the area north of the road is croft land, with cultivation on the sand-veneered shingle platform and elsewhere grazing. The area of grazing is used mainly by sheep, and the sward is fairly close cropped, but there were very few rabbits. Access from the road is very easy, and the machair clad sand hill is used on a small scale as a caravanning and camping area. The site is very restricted however, and there are very definite physical limitations on its capacity. Pedestrian access from the sand hill to the beach is easy, but a track has developed down the eroding front edge of the hill, which can only aggravate the already serious erosional situation.

The Clashnessie machair is eroding back very rapidly, so much so that occasionally the road is blocked or nearly so by accumulations of blown sand. The situation is so far advanced that merely prohibiting caravanning on the machair will not halt the erosion, which is only caused to a relatively minor extent by tourist activity. If the remaining part of the sand hill is to be saved, much more radical action would be required, such as planting marram along the face of the hill, or better still turfing it. The area affected, although a sizeable proportion of the total beach area, is not large in absolute terms so that protective operations should not prove to be unfeasible. If these works could be carried out, there is no reason why the present small scale utilisation for caravanning should not be allowed to continue, provided that the access from machair to beach was properly channelled along strengthened tracks, and was not allowed to spread out haphazardly and thus form multiple tracks.

5.4 Scourie

Morphology (Figure 8.4), Vegetation (Figure 6.4), Exposure (Figure 5a), Photograph 4.

The shingle and sand beaches of Scourie lie in the hillgirt innermost part of the bay which leads out to the open Minch and the well-known seabird reserve of Handa Island. The beach areas are almost completely enclosed by a prominent reef of Lewisian rock which runs out from the west headland. At low tide the wide western sand beach dries completely and water of less than 1 fathom is found in the remaining part of the bay which fronts the shingle beach and small pier.

The area is thus more akin to a tidal strand than a true coastal beach and is the result of sedimentation in a protected basin-structure in the Lewisian country rock. The type of sedimentation in the two beach areas has been quite different since one beach is of sand, the other of shingle and cobbles. The east beach is of cobbles and shingle and faces due west to the narrow sea entrance through which passes strongly convergent wave action. The strength of the waves in spite of the shallow sediment filled offshore ground has resulted in a large shingle bar to be constructed across the east end of the bay. This bar has blocked the drainage from Loch a'Bhadaidh Daraich and impounded a marshy pool which drains by seepage through the shingle bar. The road to the almost disused pier uses this natural causeway. Storm thrown cobbles on either side of the road show that the ridge is still active at times when westerly gales and high tides coincide.

The west bay is entirely different. It is subject to gentle, much refracted wave action and the beach is of very low gradient. An index of the low energy depositional environment is the texture of the dune sand derived from this beach: the sand has a median diameter of 196 microns which is very fine – cf. Clachtoll 388 and Sandwood 460 microns. The shallow water and low gradient make this a very safe beach and as the area is very well protected by its ring of hills (Figure 8.4) the area has some advantages over other beach areas in this northwest coast.

The source of the beach sand and shingle can only be suggested as having come from a glacial or outwash source since no sediment source is found in cliff erosion or drainage. The landscape, in general, consists of the characteristic ice-worn Lewisian plateaux, hills and ridges but pockets of angular, stoney till are visible in several localities nearby as for example in the steep hill slope north of the pier.

In spite of the constriction of the area and the protection offered by its general setting some sand blowing has occurred on a very local scale from the west beach. This has resulted in the rock peninsula (already referred to) being covered in undulating and broken machair topography. A ledge of sand borders the upper part of the beach and in the extreme western angle of the beach a small sand hill complex has developed. The seaward edge of this sand ledge is subject to slumping and undercutting but inland the machair ground is quite stable since it is fenced off and still under arable agriculture. As shown on Figure 8.4, however, this is a very small feature indeed and is further reduced by the width of the metalled road leading from the village to the graveyard which occupies most of the small sand promontory already described.

The area is so small and the parking so restricted that it is surprising to find any caravans here but they are parked along the edge of the road and near the graveyard on the west beach and on the shingle ridge and near the almost disused plot on the east beach. It is difficult to ascertain to what extent these caravans are

entirely seasonal tourist phenomena or semi-permanent habitations for people working in the Scourie area, for Scourie is a relatively important local service centre, but the area has no capacity at present for such development near the beach although suitable land could probably be found nearby particularly between the main road and the two 'B' roads which give access to the settlement axes of Scourie More and Scourie Village. Were it not for the fact that this is the only beach area between Clashnessie to the south and Oldshore More to the north which are 90 miles apart by road it is doubtful if the bay would have any great tourist attraction at all.

Photograph 4 Scourie – West bay at high tide. Constricted machair area.

5.5 Oldshore More

Morphology (Figure 8.5a), Vegetation (Figure 6.5), Exposure (Figure 5b).

Oldshore More beach is located about 2 miles northwest of Kinlochbervie on a northwest-southeast trending section of the coast. The beach is about 700 yards long, and has an inter-tidal zone of 200 yards, with the upper beach between high water mark and the dune front 35 yards wide. It occupies a depression in the Lewisian gneiss basement, with small remnants of Torridonian sandstone in the axis of the depression, offshore in Eilean na h-Aiteig and in a number of reefs and skerries. The depression trends southwest and is asymmetrical with a steep southeastern edge and a more gently sloping northwest margin. It seems very likely that a faultline marks the southeastern edge, and indeed faulting may be responsible for the existence of a number of minor but important ridges within the depression. The most striking of these ridges is the one of Lewisian gneiss on which the graveyard stands, and which in effect forms the southeast headland to the bay. To the northwest another gneiss ridge occurs on the margin of the main depression, while a small remnant of Torridonian sandstone survives in the form of a small ridge occupying the axis of the depression. Thus the grain of the relief and of the drainage entering the bay runs in a northeast-southwest direction. The submarine contours appear to follow the same general trend with the ten fathom line about 800 yards offshore.

The rock ridges are for the most part ice scoured and lacking in any weathered layer or superficial deposits save for occasional perched boulders and very thin and discontinuous till. It is likely that the same is true for the offshore ground, which appears to be mainly rocky although the inner part of the bay is floored with sand.

Marine erosion is most active on the strongly exposed northeast headland, on Eilean na h-Aiteig. Here the sandstone beds dip towards the northwest, and a cliff has been cut around the south and east sides. Cliffing has also taken place on the reefs of sandstone in the northern part of the beach, and in the sandstone remnant occupying the axis of the depression, although the latter is at present above high water mark and is protected by an accumulation of sand. The Lewisian sections of the headlands have not been cliffed, except on part of the inside of the southeast headland where the rock has apparently been weakened by faulting. Part of the source of supply of material to the beach will be from the erosion of nearby cliffs.

Occasional undercutting of the front of the main dune ridge does occur during storms but this undercutting is not serious and is more than balanced by accretion accompanied by active marram colonisation. Indeed in terms of marine processes the beach appears to be fairly stable, with a low $^{c}/_{p}$ ratio of 2.93. It is, however, slightly skew, with an $^{a}/_{b}$ ratio of 1.86, and seems to be twisting round in a clockwise direction, with accumulation occurring on the eastern half.

The material accumulating on the beach is a fine shell sand, except on the northwest where shingle and cobbles occur under conditions of greater exposure.

Most of the sand is of a finer calibre than that which should be liberated by erosion of the Torridonian sandstone, so that there must be other supplementary sources. The small stream entering the bay is unlikely to contribute large quantities of material, as it flows over ice scoured Lewisian gneiss, although it may be able to acquire a small quantity of blown sand which it will return to the beach. However its overall role in terms of its erosional as well as its depositional work is likely to be small. Immediately to the south of the gneiss ridge on which the graveyard stands, another larger stream enters the sea via a small bay. This stream

is much longer, and has cut a considerable slit in solid rock upstream, but once again its load is likely to be fairly small since it passes through Loch Aisir Mòr about 1 mile to the northeast, which will act as a filter in removing much of its sediment load.

Inland from the upper beach lies the frontal dune ridge, broken by the stream exit but otherwise continuous. The ridge appears to be fairly stable, with only a few small blowouts. Behind the dune ridge however, a complex of old deflation hollows and sand hills occurs between the Torridonian sandstone and Cemetery ridges. For the most part this area is well vegetated and is fairly stable today, although erosional activity must have been vigorous in the past. One large and a number of small blowouts still exist, although erosion does not seem very rapid. Behind this area of fairly deep sand, the topography of which seems to be uninfluenced by the underlying rock topography, lies an extensive area of thin sand forming a veneer of variable thickness over the rock ridges. Between the Torridonian ridge and the northwest margin of the depression, this thin veneer thickens out in a zone of flat machair, where once again the underlying topography is of little influence, although the bedrock is at a higher level than further east. This flat machair area is stable and little affected by wind erosion, although on the sand veneered slopes of the rock ridges a large number of small erosional scars are in evidence.

The vegetation sequence from the beach front inland is essentially similar to that depicted in the type profile in Figure 4. On the dune front, young marram communities are colonising, while in the complex of old blowouts and sand hills behind the dune ridge a much closer and more mature community of marram together with other grasses and mosses exists. Further inland still, on the flat spreads and veneers of blown sand a typical machair sward with a close turf occurs. On the headlands and on Eilean na h-Aiteig the vegetation communities are adapted to exposure to salt spray, while further inland beyond the limits of blown sand and salt spray the maritime communities give way to moorland or croft land.

Most of the area affected by blown sand is common grazing, although the estate was not able to provide a map depicting the limits of the grazing, nor was there agreement between the local crofters interviewed as to where the limits lay. A sheep stock is carried most, but not all of the year, on the common grazing.

Caravanning is little practised, but a number of chalets have appeared within a short distance of the beach area, and access to the beach is fairly easy. A tarred road leads from the Kinlochbervie-Sheigra road down as far as the Cemetery on the east side of the beach, but does not lead on to the dune area itself. At the end of the road there is a small turning and parking area which becomes rather congested at busy times in summer, when it may contain 25 or more vehicles. Another means of vehicle access to the beach area is via an unmetalled track leading across the machair area much further west. This track stops high above the beach level and there is little erosion associated with it as the density of traffic using it appears to be low. Neither of the means of access are really suitable for caravan traffic, and there is no attractive caravanning area on the machair close to the beach as at Achmelvich or even Sheigra. Consequently caravan induced damage has not arisen in the same way as at other places. Instead the pattern of use seems to be one in which visiting rather than residential tourists predominate.

One or two very small areas of slumping and blowing of sand occur along the line of the footpath leading from the car park past the Cemetery to the beach. However, these are very localised and insignificant, and there is no evidence that the beach is being misused or over-used for recreational purposes. Indeed it could be concluded that Oldshore More is one beach that could carry a greater intensity of use, provided that

care was taken in planning for this greater use. One possible danger point lies in the unmetalled vehicle track across the machair, which is unsuitable for more frequent traffic use than is the case at present. It is recommended that if caravanning facilities are to be increased, they should be provided near to or even inland from the Kinlochbervie-Sheigra road, rather than on the small area of flat machair that does exist, as is the case for the existing small caravan park. However, there seems to be no physical conservational reasons which would preclude an increase in the existing chalet developments, although it would be hoped that more attention would be paid to visual amenity than has been the case to date.

In conclusion Oldshore More beach is fairly stable both in terms of physical processes and recreational use. Some scarring is occurring at present, but this is mainly associated with rabbit burrows, and does not seem connected with tourism developments. No reduction in intensity of use is thus recommended, and indeed it is suggested that if care is taken, more use could be made of the beach.

5.6 Oldshore Beg

Morphology (Figure 8.5b), Vegetation (Figure 6.6), Exposure (Figure 5b).

Oldshore Beg or Polin beach is located immediately to the west of Oldshore More, and has a similar orientation and boundary characteristics. The beach is about 300 yards long and has a very wide inter-tidal zone of almost 300 yards, with 30 yards of upper beach separating the dune front and high water mark. Like Oldshore More, Oldshore Beg beach occupies a southwest trending depression in the Lewisian gneiss basement, but unlike Oldshore More, no remnant of Torridonian sandstone has survived. Again there is a slight asymmetry, with the southeast margin much steeper than the northwest one, and faulting again being likely. The depression is fairly narrow however, and does not contain the small ridges of the type which complicate the morphology of Oldshore More. Off the northwest headland is the island of Eilean an Ròin Mòr, which is a continuation of the ridge form of the headland. This island is of great importance in increasing the shelter of the beach from the west quarter. Also deep water does not come so close inshore as in the case of Oldshore More. Although the depression is continued offshore the ten fathom line is three-quarters of a mile out. The rock ridges forming the margins of the depression are ice scoured and present the typical appearance of bare Lewisian gneiss topography, with a very thin or completely lacking cover of weathered material or glacial deposits. It is likely that the offshore ground is of similar nature, being for the most part rocky with some sand in the inner bay.

The beach is moderately well sheltered (Figure 5) except for the southwest quarter which is very open and exposed. The morphology of the blown sand area would suggest that winds between south and southwest are most important in its evolution. Marine erosion is mainly confined to the headlands. The Lewisian gneiss does not readily yield cliff forms, but some cliffing has occurred on the insides of the headlands where the rock has probably been weakened by faulting. On the much more exposed headland extremities, comparatively little cliffing has occurred. Only very small quantities of sediment would be available from local erosion, and most of the beach material must have come from another source. Very little undercutting of the dune front has occurred, and in terms of marine processes the beach appears to be very stable. The $^{c}/_{p}$ ratio is fairly low at 4.40, and the beach is practically symmetrical, showing no tendency to re-orientate itself. Most of the material accumulating on the beach is a fine shell sand with no shingle or cobble deposits, in contrast to the exposed cobble beach at Droman immediately to the west.

The stream which enters the bay might be expected to supply small quantities of sediment to the beach, but for the most part it flows over gneiss so that its load will be very limited, and certainly will be insufficient to account for most of the material accumulated on the beach area. However, the stream has in its lower stretches cut down into the machair, so that a certain amount of sand will be in circulation between beach, machair and back to the beach via the stream.

Inland from the upper beach lies the frontal dune ridge, broken at its eastern end by a deep re-entrant at the mouth of the stream. The ridge is stable with very few blowouts, and quickly gives way on its distal side to a zone of very gently undulating local topography, in which faint ridges run inland at right angles to the dune direction. This zone in turn gives way to machair, which is very stable except for a few subdued traces of blowouts and accumulation ridges. Nowhere is the infill of blown sand likely to be deep, as rock outcrops by the stream outlet on the upper beach, but the sand thins into a veneer against the gneiss slopes of the west side of the depression. In contrast to the stability of the flat machair, the thin, sloping machair appears

to be very susceptible to erosion, and numerous blowouts, some of which are quite large, have developed. These blowouts are closely associated with rabbit burrows, and can be subdivided into three types. The first, largest and most dangerous type is the type occurring between the Allt a'Blàir Mhòir and the gneiss ridge. Here the blowouts present a crescentic shape, the concave eroding edge facing southwest and the prevailing wind. These blowouts seem to have originated at the break of slope between the thin sloping and the flat machair, and have spread down onto the flat machair. The second type of blowout is a more linear type of feature, and is best developed to the west of the west headland ridge crest. The blowouts are orientated parallel to the presumed prevailing wind direction, and parallel to the ridge orientation. At the leeward ends, they sometimes open out to present a face at right angles to the wind direction, although they are more frequently linked at their windward ends to present a very crenulated front edge. The third and rarer type is also a linear feature but this time it is orientated at right angles to the wind direction rather than parallel to it. This type of blowout is mainly confined to the ridge crest. As the geomorphological map shows (Figure 8.5b) blown sand its largely confined to the west of the stream draining the depression, and does not spread over the eastern ridge. This would imply that the south wind is a much more important transporting agent than is the west. Exposure to the south is severe, while the gneiss ridge affords shelter from the west.

The vegetation pattern is simple. Active colonisation is occurring on the landward part of the upper beach, while the open marram community of the front part of the dune ridge rapidly gives way to more fully developed turf forming communities on the lee side of the ridge. On the blown sand inland from the dune ridge, typical machair communities have developed, while along the stream sides freshwater marsh communities exist in the poorly drained hollows. The headlands are uninfluenced by blown sand but salt spray is an important modifying factor on the vegetation. The greater part of the machair area is common grazing. The flat machair its part of the grazing of Polin (Oldshore Beg) where sheep are taken off in summer, while most of the thin machair on the gneiss ridge is the common grazing of Balchreick, where grazing is carried on all year round. It seems likely that sheep rubbing will aggravate erosion on some of the blowouts of the latter, although the initial causal factor seems to be rabbit burrowing.

Vehicular access to the beach, dune or flat machair areas is not possible. A road leads from the Kinlochbervie-Sheigra road to Oldshore Beg township, but does not extend down to the beach, and the parking of cars in the township and pedestrian access from there to the beach seems to be discouraged. Another road runs to Droman pier, to the west of the gneiss ridge forming the boundary to Oldshore Beg Bay. A small area close by the pier is used as a parking space, and indeed in a small way as a camping place, but again there is no vehicular access to the beach, although the ridge is not fenced and walking is fairly easy. Thus because of the difficulties of access, the beach and beach area is comparatively little used for recreational pursuits. Caravanning is impossible because of road access, and the only type of use that is carried on is that of a short visit. Not surprisingly, there is little sign of tourist damage to the beach area, and the erosion that is taking place is due to other factors.

In conclusion, it could be suggested that Oldshore Beg beach is capable of more intensive use than is the case at present. It is unusual, however, in that access and accessibility to it are not particularly easy, although it is not far from motorable roads. This relative inaccessibility might allow it to be retained as a sort of "wilderness beach" without any of the trappings, of tourism, although there are no purely physical reasons to preclude an increase in amount of use made of it.

5.7 Sheigra

Morphology (Figure 8.5c), Vegetation (Figure 6.7), Exposure (Figure 5b).

Sheigra beach is located at the turning point between the northwest and north trending sections of the coast at the mouth of the Loch Inchard embayment. It is about 3½ miles northwest of Kinlochbervie and is situated near the end of the Kinlochbervie-Sheigra road. The beach and beach area are fairly small. The length of the beach is about 200 yards and the inter-tidal zone is about 60 yards wide.

Like the other Loch Inchard beaches, Sheigra occupies a southwest trending depression in the Lewisian gneiss basement. Unlike the other beaches, however, the eastern headland is not of gneiss but of Torridonian sandstone, and the depression is excavated along the contact between the gneiss and sandstone. The eastern margin of the depression is bounded by a steep scarp of north-westwards dipping sandstone, while the western margin and headland present a typical Lewisian landscape of bare, ice scoured rock with occasional perched boulders. The line of the western headland is continued offshore in a submarine ridge appearing occasionally above the water surface in the form of small skerries. This ridge will have an important effect in modifying wave action on the beach. The depression also continues offshore, but it is very narrow between the Dubh Sgeir and Eilean an Ròin, and the 10 fathom line is almost ¾ of a mile offshore. It seems likely that the offshore ground is as bare and driftless as the shore, and the small area of sand in the inner bay quickly gives way to rocky ground.

As Figure 5 indicates, exposure is very severe from the southwest quarter. Although the skerries will offer a certain amount of shelter from wave attack, the beach is very open to southwest winds. It is also comparatively open to the northeast, so that the most important wind directions are in direct opposition. The ridge margins of the depression, however, offer shelter on the northwest and southeast quarters, so that "cross" winds will not be important.

Under these conditions of fairly severe exposure, marine erosion is actively proceeding in the headlands. On the southeast headland, the Torridonian sandstone has been cliffed although it dips seawards, and even on the inside of the west headland, where it is possible that the gneiss has been weakened by faulting, some cliffing has occurred although to a much lesser extent than on the Torridonian. The beach has a slightly higher $^{c}/_{p}$ ratio (5.02) than have the two more sheltered beaches of the Loch Inchard group, and there are some signs that the beach is showing a slight tendency to re-orientate itself in an anti-clockwise direction. This seems to emphasise the importance of the skerries off the west headland in modifying wave approach.

The exposed, "high energy" location of the beach means that the calibre of beach material is larger than that of the more sheltered beaches. Indeed there is evidence in some of the sand blowouts that the machair only forms a comparatively thin layer of 6–8ft over shingle and cobbles which might be regarded as the main material infilling the depression. Also at and above high water mark a zone of very large cobbles, of average long axis length 2ft, forms a facing to the front of the machair, and although the lower beach is sandy during summer it seems likely that it may comprise much more shingle during winter. Most of the large cobbles are of Torridonian sandstone, and are well water-worn and rounded. That they are still mobile is illustrated by their lack of encrustations. The source of these cobbles, and of the shingle and cobble infill under the machair would seem to be the Torridonian outcropping in the eastern headland. Equally important to the direct wave erosion of the cliffs, however, as a source is the falling of scree blocks from the undercut cliff. Although coarse

material is still being supplied to the beach, it would seem the source is smaller than in the past when a higher sea level may have meant a period of more active cliff erosion.

The other main material is very much finer, in the form of a fine shell sand.

Like the coarse calibre material, there is strong evidence to suggest that fluctuations have occurred in the supply of sand to the beach. The strongest evidence for this is the lack of a dune zone between the upper beach and the mature machair area. Instead there is a direct transformation from bare sand to mature sward, without the usual sequence of landforms and vegetation communities illustrated in Figure 4. Instead of an intermediate zone of marram clad dunes occurring, the front edge of the machair behind the upper beach and cobble bar is being actively eroded at present. Since under natural conditions the machair could not have evolved in this way, it seems a reasonable hypothesis that at some time in the past sufficient sand must have been available for the formation of a dune zone behind which machair evolution could occur. With the exhaustion of the sand supply as the offshore ground above the wave base became swept clean, the dune system eroded away, and erosion of the machair front is continuing at present. Not only is wind erosion active, but it seems likely that wave erosion is taking place on the shingle below the machair, and this is one of the sources of the coarse material being thrown up to form a bar.

A small stream drains into the bay, but it is short and filters through a marshy depression immediately behind the machair, which will act as a sediment trap, so that very little material will be delivered to the beach from this source. Nor can the stream cut down and grade itself to low water mark, since it is important to move shingle and cobbles, and its water simply trickles through the cobble bar at the top of the beach in a very diffuse form.

The main erosion process affecting the machair area is that of wind blow. Long erosion scars have appeared orientated in a southwest-northeast depression, especially on the east side of the beach. However, erosion, although certainly taking place, does not seem to be occurring very rapidly, since there are patches of marram colonisation in some of the blowouts. Accumulation forms of bare sand inland of the scars are few, and it would seem that to a certain extent at least there is a sort of to-and-fro motion of the sand along the blowouts in response to reversing southwest and northeast winds. Certainly the erosional condition of the machair front does not seem very much worse than in 1946 when aerial photographs already show much erosional damage. The sand that is blown inland seems to be dispersed over the marshy area behind the machair, and does not spread out onto the depression margins.

As has been suggested, the vegetation of Sheigra differs from the type profile illustrated in Figure 4 in that it lacks a dune zone where pioneer communities have colonised bare sand. The machair community is typical, as is the spray modified vegetation of the headlands, although in these highly exposed headlands the influence of spray is felt far inland. Also the splash zone of bare, unvegetated rock is very wide off the outside of the west headland. The machair area forms part of the common grazing of Sheigra township, and although sheep were not in evidence during the period of investigation, the sward was close grazed and sheep are on the ground for most of the year. Rabbits were few, and it may be that the absence of thin machair over rock means that the environment is less attractive to them than that at Oldshore More or Oldshore Beg. Inland from the machair lies the croft land of the township, which still works its land in run rig.

Access across this croft land and onto the machair is very easy. A track leads from the Kinlochbervie-Sheigra road over flat terrain almost right to the machair front, so that not surprisingly caravanning and camping have developed. During the period of investigation in mid-August six caravans and six tents were on the ground, and cars were being driven right up to them. A car track has appeared from the end of the "made" track near the fence separating the croft land from the common grazing, but as yet little erosion has occurred along the track. However, at the seaward end of the track, where in any case erosion is most likely and most dangerous, some signs of erosion are in evidence where vehicle turning has taken place.

It is stressed that much of the erosion ocurring on the Sheigra machair is a process resulting from natural conditions. However, great care should be taken so that the natural erosion is not aggravated by that resulting from tourist activity. It would seem that insufficient care is being taken at present, although as yet little damage has been done. In order to try and ensure conservation as far as possible however, it is suggested that vehicles should not proceed beyond the fence separating the common grazing and croft land. Vehicle access could be allowed to station and remove caravans, at least for an experimental period until the resultant damage could be assessed, but once the caravan was established the cars should be left well back from the machair front and access to the caravan made on foot.

It is appreciated that Sheigra is an attractive caravanning area, and that it is the only beach in the Loch Inchard district where caravanning is possible. It is not, therefore, recommended that caravans should be prohibited, but simply that a slight modification in the pattern of use, involving little inconvenience to the users, be introduced to try to ensure that recreational use does not aggravate the natural processes of erosion.

5.8 Sandwood Bay

Morphology (Figure 8.6), Exposure (Figure 5a).

Sandwood Bay contains the largest beach and dune area in west Sutherland and although situated at the end of a major valley – Strath Shinary – is also the least accessible. The beach, dune and machair complex separate Loch Sandwood, which is the flooded lower part of this glacially modified depression from the sea. The southeast to northwest trending depression also corresponds to the junction of Torridonian grits and conglomerate to the south and Lewisian gneisses to the north. At its width the peninsula of sand and shingle stretches for ¾ of a mile out from the crumbling Torridonian cliffs to the loch outlet which has been forced against the Lewisian headland which forms the northern limit of the Sandwood area. Further north, however, the beach is extended by two smaller embayments corresponding to minor depressions in the otherwise almost continuous cliff rampart which extends north to Cape Wrath.

Bedrock in the form of skerries on the relatively steeply inclined lower beach and three other exposures of Torridonian and Lewisian origin within the dune complex suggest the existence of a discontinuous sill of rock which has formed the core of the land bar across the loch. In effect the physiography resembles a raised fiord or sea loch being filled in by and drift from the north and deltaic sedimentation from the Shinary in the south.

Apart from the trend and shape of the strath itself evidence of possibly more than one glaciation in abundant – on the mammillated ridge tops, the polished and plucked valley sides, the discontinuous deposits of till especially on the Torridonian and the perched, ablation erratics on both the high and low ground. The lithology of these erratics and the thin gravelly till cover on the Lewisian ridge to the north indicate the passage of ice from Torridonian to Lewisian.

The importance of different resistance to erosion can also be seen in the marine and inland cliffs which form the margins of the region. The rectangular north and northeast facing Torridonian cliffs rise steeply, in places nearly vertically to over 300ft O.D. but are visibly crumbling to form great scree and talus cones. The coastal cliffs thus provide abundant materials of a wide textural range to the inshore zone. The rate of this retreat can probably be judged from the separation of the 170ft stack of Am Buachaille to the west which could not have withstood intensive ice erosion. The massive Lewisian is generally less active being more resistant except where fractures or lines of lithological weakness have been picked out by climatic element. The cliffs are bold but have a convex profile and little detrital material is found at the cliff foot except in geos and even there the material is probably derived from moraine.

Thus the Torridonian has been and is the source of the beach materials and some supporting evidence of this is found in the coarse nature of the reddish dune sand with a median diameter of 460 microns.

Although the landscape is dominated by the influence of sand, lines of cobbles are exposed near high water mark and within the line of broken dunes forming the transverse ridge in the central part of the abayment. The thickness and width of cobbles is best seen where the loch flows out *over* a 60 yard wide ridge of sea-rounded shingle and cobbles. It is therefore suggested that the initial closing of the strath was achieved by the formation of shingle spits and bars and it is on this basement of shingle and, as previously described, an undulating series of rock exposures that the sand foreland developed.

The abundance of sand concentrated into this natural abayment now forms a beach almost 2 miles long at its maximum low water mark extension and up to 300 yards wide and with a $^{c}/_{p}$ index of 9.3 is liable to relatively rapid changes in outline and in the distribution of supra-beach features as for example berms or beach drainage. Apart from building dunes, wind blown sand has also extended machair-type landforms high onto the Lewisian ridge to the north and infilled the northern part of Sandwood Loch although the evidence of cliffing on its northern and western shores indicate how local wave action across the loch is gradually cutting back the machair and dune area. Sand influence also extends in a southerly direction along the sides of the loch and into the depression through which the access track passes.

A major area of bare sand is found above high water mark in the western corner of the area where several large blowouts have coalesced. Undoubtedly the funnelling effect of the ancient sea cliff is of major importance here. Bare sand is also found in the wide tidal pool between the line of fore dunes and the main dune and machair foreland. The flooding of this area is mainly due to fresh water being imponded by the tide but some salt water now breaks through at the west end of the dune ridge.

The main dune area is covered in vigorous marram tussocks and only locally gives way to the lower grasses of the machair association. The immaturity of the vegetation is related to the continuing activity of blowing sand. The open exposure of the area (see Figure 5a) and the frequency of very strong winds lead to long-distance and variable-direction sand transport which is the life-blood of the growth of marram and similar species. The tenacity of marram colonisation is most spectacular on the fans of screes and blown sand which form such distinctive landform units on the lower slopes of the Lewisian and Torridonian ridges. Such deflation and blowout activity is not a new phenomenon. The landforms of the entire area are a complex of old and new cycles of activity and consolidation. In places, as for example beside the northwest corner of the loch, wind erosion is compounded by flooding and marsh development and in a few of these erosion features till is exposed beneath the sand.

An equally extensive sand area spreads upwards to over 300ft O.D. on the northern Lewisian ridge. The lower slopes consist of a confusion of screes, bare rock and blown sand. The upper slopes and ridge crest is covered by a veneer of sand carrying a machair-heath type vegetation. The type of plant species appears to be related to exposure and drainage, and in the instance of some Dryas terraces on the west shoulder salt spray may also be a contributory factor in its distribution. Erosion scars are frequent and have probably been initiated by sheep or rabbit grazing. Because of their exposure and the thin cover of sand such erosion scars are quick to spread and in the relative absence of colonising species such as marram will probably continue to extend.

A small area of sand combined with scree is found north of the main Lewisian ridge where a small stream enters a depression in the gneiss. The surrounding slopes attain angles of more than 20° and the floor of the depression is retained from the beach by a high cobble ridge. The upper part of this stream course, however, trends southwards and offers a lower corridor along which sand has spread to link up with sand spreading out from the main Sandwood area. Erosion scars here reveal the basement of bedrock or the thin veneer of gritty red till.

Because of its isolation, reached only by a 2 mile footpath after a rough but motorable 4 mile peat track off the Kinlochbervie-Sheigra road, the human impact on this area is slight. Camping is forbidden by the owners, the Kinlochbervie Estate, and there is no settlement nearer than the township of Sheigra. The former

existence of a clachan at Sandwood can be seen in the shape of a crumbling house, field boundaries and sheepfold and there is additional evidence in the form of old lazybeds. Today the area is lightly stocked with sheep and is apparently used as common grazing by several townships. Rabbit stocking is also low except on the margins of the area where the sand tends to be thinner but the machair-type vegetation richer, and unfortunately these areas are quick to erode and slow to heal.

Thus the sand area of Sandwood Bay is naturally unstable and dynamic. Human impact was probably greater in the past but does not appear to have been a major influence in landscape evolution. There is no question of the area being opened up to increased pressure without considerable investment in roads and footpaths, and given the evidence of natural instability it would be very unwise to promote any form of tourist development. With its variety of rocks, landforms, plants and wildlife the area does offer an ideal area for the naturalist, field scientist and hill walker and the area may well be a suitable one to conserve for these and similar users.

5.9 Balnakeil Bay

Morphology (Figure 8.7), Vegetation (Figure 6.8), Exposure (Figure 5b) , Photograph 6.

Balnakeil Sands occupy the west side of the isthmus joining the Faraid Head peninsula to the mainland just to the north of Durness. The setting of the beach differs from the rather confined position of many of the Sutherland beaches in rather narrow inlets, and the long sweep of the beach is unique in the north and west of the county. The beach is nearly 1.25 miles long, with an inter-tidal zone averaging over 200 yards wide. Half way along, the line of the beach is broken by a rocky protuberance washed at high tide, and further north the reef of A'Clèit, which is exposed at low tide, exerts an important influence in the beach orientation.

Structural influences are very strong in the orientation and morphology of the beach area. Faraid Head peninsula consists of a block of gneiss tilted towards the southwest and terminating on its north and west sides in high cliffs. It is connected on its southern margin to another tilted block, this time of schist. Both of these blocks appear to be fault-bounded, and another fault-line runs west-east across the south side of the bay separating the metamorphic rocks from limestone. Thus the structure is simply that of two blocks tilted towards the southwest, presenting an inclined plane up which large quantities of sand are progressing in a northeasterly direction. The Kyle of Durness opens out into Balnakeil Bay at the line of the fault marking the northern limit of the limestone. The Kyle is very shallow, with very extensive sandflats exposed at low water. Much of the material composing these sandflats is of glacial or fluvio-glacial origin, and it is likely to be the source of most of the sand on the isthmus. Occasional patches of drift are exposed on the east side of the isthmus, but for the most part the blanket of blown sand has obscured all underlying materials. Off the east side of the peninsula the ground appears to be mainly rocky, although an extensive sand bank stretches from off Aodann Mhòr headland almost to Eilean Hoan. On the east, north and northwest sides of the peninsula, deep water approaches closely to the land, while in the bay the submarine contours are practically parallel to the coastline and the ground shelves gently outwards.

The protruding configuration of the peninsula means that conditions are fairly exposed (as Figure 5 indicates), especially from the northwest quarter which is very open. The skerries off the north beach will lend some protection from wave attack, but the beaches are completely open to the wind.

Marine erosion is active around the headland, but on the east side of the peninsula a wide abrasion platform has formed which gives a measure of protection to the cliffs which are now mostly inactive. On the short east-west section, coinciding with the faulted block edges, however, active cliffing is still proceeding, and the existence of stacks, such as the Clach Mhòr na Faraid testify to the cliff recession which has occurred. On the southern boundary of the beach, the land is much lower and is composed of limestone, so that the cliff morphology and erosional processes in operation differ from those on the peninsula. The rocky protuberance midway along the beach (the west end of the Meall a'Bhuic ridge) is bounded by a cliff, which if not actively being eroded at present is at least being washed clean of any weathered and slumped material at high tide. Some erosion of the dune front is taking place, especially on the north beach and on the northern part of the south beach. There is very marked undercutting and slumping of sand on the dune front, even behind the skerries, but this erosion is to some extent balanced by accretion at the south end of the beach. Measurement of the beach parameters vary tremendously depending on whether high or low water mark measurements are made. At low water, the skerry A'Chlèit functions as the hinge point between the north and south beaches, and the $^{c}/_{p}$ ratios are fairly low at 6.5 and 3.7 respectively, although even

here the north beach is clearly more unstable than is the south beach. At high water, when the hinge point between north and south is further south, at the extremity of the Meall a'Bhuic ridge, the contrast in the $^{c}/_{p}$ ratio is magnified, the north beach becoming convex in plan. These theoretical considerations agree closely with observations on the ground, and the evidence would suggest that the beach is tending to rotate in a clockwise direction, erosion at the north end being balanced by accretion at the south end. This changing orientation may be in sympathy with changes in the supply of material from the bay as the ground above wave base becomes swept clean of transportable sediment.

Fluvial processes in the beach area are of very minor importance. A short stream, ditched along part of its course, drains the depression across the neck of the peninsula, but achieves little erosional or sediment supply work. Another short stream drains Loch Croispol and is controlled by a sluice. In contrast to the impotence of fluvial processes, however, aeolian processes have been of great importance in the evolution of the topography, and still are powerful agents of landscape change in the northern part of the isthmus.

The isthmus is characterised by a large number of northeast trending sand ridges some of which are 100ft or more in height, climbing up the inclined plane of the tilted blocks. These ridges are particularly in evidence at the north end of the beach, and at either side of the Meall a'Bhuic ridge. For the most part the sand ridges are fully vegetated and fairly stable at present, although at some period in the past they must have been very mobile. At their northeastern end some of the ridges connect up with each other by short arcuate ridges, so that in plan they have an exaggerated horseshoe or parabolic shape. Separated from the southwest end of these ridges by a discontinuous depression parallel to the beach, runs the frontal dune ridge, which is a much broader and less steeply sloping feature than are the northeast trending ridges. The south end of this frontal dune ridge is fairly stable, although a blowout has been excavated near the stream outlet, and indeed accretion has been actively occurring at the front edge of the dune, and many embryo dunes are in the process of establishment. Further north, however, at the north end of the south beach, and more particularly on the north beach, blowouts on the ridge become much more numerous. On the north end of the south beach, the blowouts are mostly small, although they may be 30ft or more in depth, and are orientated in a northeast direction. On the north beach, in contrast, the blowouts are very large. Undercutting of the dune front has presented an unprotected, unvegetated face on which the wind can act, and in some places the ridge has been removed almost down to high water level. Behind these large, broad blowouts, broad ridges of bare sand have accumulated, and in places have encroached on the road leading to Faraid Head. Within some of the blowouts a complex of minor blowouts and accumulation ridges occur, and at the mouths of some of them embryonic dune formation is beginning, indicating that natural healing processes are still in operation. Comparatively little wind erosion is occurring on the inland, northeast trending ridges, except in a few localities, and practically no erosion is taking place where they flatten out to a flat machair on the northeast corners of the tilted metamorphic blocks.

The vegetation sequence is similar to that illustrated in Figure 4. On the seaward edge of the frontal dune ridge, pioneer communities, with open marram, are colonising, while further inland more mature marram communities clothe the ridges. Between some of these ridges marshy vegetation occurs in the dune slacks, while on the thin, flat blown sand of the Meall a'Bhuic ridge and Faraid Head typical machair communities occur.

The land tenurial pattern is simpler than that at most beaches, with the absence of common grazings. The land is part of Balnakeil Farm, and is used as rough grazing for cattle and sheep. The grazing potential is not high, and there are no signs of overgrazing on the part of domestic stock or of rabbits, which are not

very numerous. A military installation exists on the top of Faraid Head, to which a tarred road has been constructed. However, this road has suffered from submergence by sand, and access along it is not possible for normal vehicles.

The pattern of recreational use tends to be one of short visits during which the tourists walk some distance along the beach and then return to their cars parked at the road end between the churchyard and Balnakeil Farm. Caravanning is not possible because of physical problems of vehicular access, except to a very small extent close by the road end. Thus there are few signs of tourist damage to the environment, and it is particularly noticeable that erosion is concentrated at the little visited north end of the beach, rather than the more fully utilised south end. In terms of the physical conservation of the beach and blown sand area, there seem no reasons why fuller use could not be made than at present. In particular, it could be suggested that pressure at Sango Bay might be reduced by the provision of caravanning facilities near Balnakeil Bay, whose south, and potentially most used, part should be sufficiently resilient to withstand more use than is made at present.

Photograph 6 Balnakeil – Parking and caravan area by open ditch at south end of peninsula.

5.10 Sango Bay

Morphology (Figure 8.8), Vegetation (Figure 6.9), Exposure (Figure 5b), Photographs 5 and 7.

Sango Bay (Sangomore) is situated on the root of the Balnakeil peninsula very near to Durness and is close to, and readily accessible from, the main north coast road. The beach is over ½ a mile long, although it is divided into three parts by rocky protuberances. The inter-tidal zone is nearly 150 yards wide, with a small area of upper beach between high water mark and the cliff-foot at the extreme southern end of the beach. The general trend of the coastline is northwest to southeast, although a number of fairly small indentations, usually connected with the geological structure, complicate the trend.

The geological structure is very complex. The north headland of the beach, Creag Thairbhe, is of limestone, and marks the fault-bounded northern limit of the limestone outcrop. Immediately to the north of this headland, another small beach, Geodha Brat, occupies a depression in the downfaulted schist block. The Sango Bay itself coincides with an outcrop of gneiss and schists which have been weakened by movements associated with the Moine Thrust, and the small rocky headlands jutting out into the bay are explained by local variations within this metamorphic outcrop. The south headland is of limestone, which is separated from the metamorphics by another fault which trends in a northeasterly direction and which forms the southern boundary of the beach. Inland the depression in the metamorphic rocks is continued in the gently sloping Sangomore valley, but the valley hangs above the beach from which it is separated by a cliff of 50 or more feet high. The offshore ground shelves out very gently. The five fathom line is almost ½ a mile offshore, but further out the depth increases more rapidly. Glacial till has been deposited in the Sangomore valley right up to the cliff edge, and the deposits probably continue offshore. In the inner part of the bay the ground appears to be sandy, although further out there is much rocky and weedy ground. To the northeast there is a large stretch of sand extending from off the Aodann Mhòr headland almost to An Dubh-sgeir immediately to the northeast of Eilean Hoan (Figure 3).

Exposure is very severe to the northeast quarter, as Figure 5 indicates. The inner bay is littered with many small stacks and fragments of a now buried abrasion platform, which lend some protection to the cliff-foot but there are no large reefs or skerries offshore to refract the wave pattern and to give rise to atypical beach plans such as those of Sangobeg and Traigh Allt Chailgeag. Likewise there is no shelter from winds blowing from the north or northeast, and this very strong exposure to these winds has meant that sand has been able to surmount the barrier of the cliff and spread out over the cliff top.

Despite the strong exposure, comparatively little marine erosion is taking place. Active cliffing is no longer occurring at the back of the beach, although occasional undercutting of the blown sand accumulation protecting the cliff-foot still occurs. The narrow headlands jutting out across the beach are still subject to erosion, and the stacks and skerries immediately offshore testify to cliff recession that has gone on. The north headland of Creag Thairbhe is being eroded, especially on its north side where the cliff line coincides with a fault, while the limestone on the south headland is also being attacked by the various erosional processes affecting that rock.

In terms of marine processes, the beach is moderately stable, with a $^{c}/_{p}$ ratio of 8.50, although the presence of the small headlands trisecting the beach complicates the calculation of the ratio. The beach is tending to rotate in an anti-clockwise direction, with material being swept into the southeast corner of the

bay, where the groyne-like headland prevents further movement. This tendency towards accretion in the southeast corner of the bay is further evidenced by the formation of small offshore sandbanks at the limestone cliff-foot.

Comparatively little of the material of the beach is derived from local cliff erosion, especially since limestone erosion is unlikely to yield sand. Most of the beach sand must be derived from offshore glacial deposits, although a certain proportion of it may be reworked material which has been blown right across the Balnakeil peninsula and into the sea once again. Another source of small quantities of sediment will be the small stream flowing into the middle of the beach.

The blowing inland of sand from the upper beach and inter-tidal zone is greatly restricted by the cliff backing the beach. The presence of this cliff means that the area affected by blown sand is confined to a narrow cliff top zone and evidence of accumulation forms and sand-modified vegetation disappears very rapidly inland. However, quite large accumulations of sand have built up against the cliff-foot, particularly at either end of the beach, and these accumulations act as inclined planes facilitating the movement of sand up the cliff and onto the flat cliff top. On the cliff slope a few erosion scars have appeared in the extreme southeast but the main process in operation is slow soil creep. Active marram colonisation is taking place on the mounds of sand piled up against the cliff-foot, but further up on the straight slope relative stability is evidenced by the presence of machair swards. Likewise on the flat spreads of blown sand on the cliff top, where sections show evidence of a number of periods of active blowing followed by long periods of relative stability during which soil formation occurred, the main form of vegetation is the machair sward. On the central parts of the cliff top, severe wind erosion is proceeding, which has completely stripped the layer of blown sand in places and exposed the underlying till. On the north section, near the headland at 407680, a long sand face has developed orientated parallel to the cliff line and facing northeast, which is presumably the direction from which the most damaging winds have occurred, although it seems that southeast winds have also had an influence in extending the face. The method of advance of this, and many other scars, is for fresh sand accumulation to occur on the lip of the scar, and unless vigorous marram is present, kills off the protective vegetation cover and so promotes the collapse of the undercut upper layers of sand. In the central part of the cliff top, stripping has occurred right back to the line of the road, and sand accumulation and recolonisation by vegetation is beginning to resume. The exhumed till provides a relatively hospitable medium for vegetation development, however, so that the stripped surface is less unsightly than would have been the case had the till not been present. Wind erosion is also proceeding rapidly on the southern section of the cliff top, the area most used for caravanning and camping at present. Here again most of the scars are linear features orientated roughly in a northeast to southwest direction, although in places, particularly on the small protruding headlands, there is a strong southwest to northeast element in the orientation. The extreme northern section of the beach, between the narrow headland at 407680 and Creag Thairbhe is backed by a steep cliff of 70ft or more in height, and no blowing inland of sand has occurred so that here the cliff top is sand free.

Unlike most of the machair or blown sand areas investigated, the blown sand zone of Sango Bay is very narrow. Nevertheless, this blown sand or machair zone has been separated in terms of tenure and use from the croft land and is part of the common grazing, with sheep being grazed all the year round. Sheep rubbing appears to be closely associated with the extension and enlargement of erosion scars, and rabbits probably played a part in the past. The locational attractiveness and ease of access from the road of the cliff top machair means that the main use at the present day, at least in summer, is for caravanning

and camping. The completely stripped area is not used by tourists, who tend to concentrate on the more southerly section to the southeast of the stream. Here extensive tracking has occurred, with multiple track formation and the destruction of the vegetation cover in places. This practice can only serve to aggravate the natural erosional processes already in operation and lead to the further run-down of the environment. Indeed there is an atmosphere of great untidyness, perhaps temporarily accentuated by constructional work on a new sewage outlet. It is suggested that efforts be made to improve the visual amenity of Sango Bay, as well as to try to ensure physical conservation, and an important first step in this direction would be the prevention of caravanning. It is suggested that the provision of caravanning facilities at a nearby more resilient beach such as Balnakeil might help to alleviate the pressure, and it is to be hoped that eventually Sango Bay will be able to revert to a natural beauty spot free from all signs of recreational squalor.

Photograph 5 Sango Bay – Caravans and erosion scars on clifftop machair.

Photograph 7 Sango Bay – Cliff-backed beach with small stacks.

5.11 Sangobeg Sands

Morphology (Figure 8.9a), Vegetation (Figure 6.10), Exposure (Figure 5b).

Sangobeg Sands occupy a small embayment in the northwest to southeast trending coastline about two miles to the east of Durness. The beach is nearly 300 yards long and 150 yards wide, with a very narrow upper beach a few yards across. The nature of the terrain backing the beach restricts the blowing of sand inland, and maritime influences are confined to a very narrow zone.

The underlying rock is Cambrian Piperock, but the headlands are composed of different rock types, and structural influences are strong as in the other beaches of the Durness group. The western headland is composed of limestone, which is separated from the Piperock by a fault, while to the east lies Cambrian quartzites. Along the shore of the eastern part of the beach, however, there is a narrow outcrop of gneiss, which also occurs in a knoll backing the middle of the beach. Inland a depression bounded by steep margins occurs, with a veneer of glacial till of variable thickness. Offshore this till deposit seems to thin and become discontinuous, most of the ground except for the inner part of the bay being rocky or weedy. About two miles out, however, there is an extensive bank of sand parallel to the coast. The water offshore is shallow and gently shelving, with the underlying rock platform, cut mainly in limestone, appearing above water in the form of skerries and the fairly sizeable island of Eilean Hoan. These offshore skerries protect the beach area and neighbouring headlands from wave attack, and the fetch is very short except for a narrow sector to due north, and an equally narrow sector to the east-northeast.

The relatively sheltered position of the beach behind the offshore skerries means that little marine erosion takes place. Some erosion occurs on both headlands however, but especially on the western limestone one. Here there is evidence of attack by sea levels higher than that of today, in the form of caves, wave cut notches and abrasion platforms all standing above present high water mark. However these features grade into similar ones still evolving today, although the ledge vegetation on the limestone cliffs might suggest that retreat of the cliffs is slower than formerly. The limestone is close bedded, and dips very gently seawards, so that conditions are conducive to cliffing. On the eastern side of the headland, an entirely different type of rocky coast occurs on the gneiss, where the massive structure does not readily form cliffs and the profile tends to be convex and rounded. Neither of the headland areas or nearby sections of coast are likely to yield large quantities of sand for beach nourishment. The limestone will tend to dissolve rather than form sand, and the material eroded from the gneiss would tend to be large clastic fragments which would be in the cobble rather than sand calibre.

A second potential source of very limited quantities of sediment is the small stream which flows into the centre of the beach. The gneiss knoll behind the beach deflects one branch of the stream far to the west so that it flows through a marshy depression parallel to the beach and this marsh will act as a sediment trap and reduce the already small quantity of transported material. The other possible source of sand is from the offshore ground where glacial deposits have been laid down, and there is strong evidence to suggest that a large proportion of these deposits lying above wave base have already been swept onshore.

In terms of marine processes, the beach is relatively stable. Calculation of the $^{c}/_{p}$ ratio is not possible, however, because the beach is convex seawards in plan, a repercussion of the influence of the offshore skerries. There is no marked tendency of the beach to re-orientate itself, although undercutting by storm

waves of the machair front is most noticeable on the eastern part of the beach. This undercutting has exposed deposits of shingle under the blown sand, and it seems likely that this shingle, which is mainly of fairly angular quartzite fragments, is a raised beach. The shoreline of this raised beach is represented by a subdued cliff cut in till a short distance inland, and it is significant that the boulders with which the surface is strewn are completely lacking seawards of the till cliff. The shoreline was not levelled but is only a few feet above high water mark. Sand has blown inland over this raised shingle beach to give a very narrow zone of machair parallel to the shore. There is quite a steep reverse gradient of about 10° on the machair, which is little affected by erosion scars. Some marram colonisation is occurring at the eastern end of the beach where sand has accumulated against the undercut machair front, but otherwise the dune zone typical of the area found between the beach and machair (Figure 4) is lacking. The influence of blown sand on the vegetation is confined to the narrow machair fringe, and quickly dies out inland where the vegetation is typical of reverted croft land and moorland, although some bracken exists on the freely drained cliff cut in till backing the raised beach. Along the stream sides freshwater marsh communities occur, while on the limestone cliffs of the western headland a rich flora occupies the ledges. Croft land approaches close down to the beach and although most of the land is under a rather poor form of grazing it is not cultivated. Grazing is fairly intensive, both by sheep and by rabbits which are numerous, and the sward is close cropped. Rabbit burrows are very numerous on the reverse gradient of the machair, but since there is shelter here from strong winds the burrows have not been enlarged into erosion scars.

Vehicular access to the beach for cars and caravans is not possible, and the beach and machair areas are consequently unused for caravanning. Nor is pedestrian access particularly easy, since it is through croft land. The beach is thus little used for any recreational purpose although it is scenically attractive and a good view of it is obtained on driving eastwards along the road from Durness. Physical factors probably preclude the utilisation of the beach on any large scale in the foreseeable future, but the sands are relatively stable in terms of both marine and aoelian processes and there would appear to be no conservation drawbacks to development.

5.12 Traigh Allt Chailgeag

Morphology (Figure 8.9b), Exposure (Figure 5b).

Traigh Allt Chailgeag is an attractive cliff-foot beach easily visible from the main north coast road about three miles east of Durness. The beach is about 400 yards long and is gently shelving, the inter-tidal zone being nearly 300 yards wide. From the cliff top backing the beach an attractive view is obtained across the mouth of Loch Eriboll towards Whiten Head. The rock underlying the bay and headlands is Lewisian gneiss, which has been fractured by a northeast trending fault line along which the inlet has been excavated. The cliff wall backing the beach is broken by three steep-sided valleys separated by minor headlands. The most easterly of the valleys is graded down to sea level, but the other two are perched high above modern sea level. For the most part the gneiss is ice scoured and lacking in a layer of weathered material or drift, but in the valley depressions deep weathered rock has survived in places and there are also patches of thin, discontinuous till. Offshore there appear to be fairly extensive stretches of sand which probably represent reworked glacial deposits.

The beach area is very sheltered from the west and south by the high cliff backing the beach, as Figure 5 indicates, but exposure to the northeast quarter is strong. Not only is the beach fully open to winds from this direction, but the fetch is very much wider than for most of the other beaches of the Durness group. Eilean Hoan gives some protection from the north but the wide sector between it and Whiten Head is fully exposed, and deep water comes closer in than further west. Despite this strong exposure, however, comparatively little marine erosion is taking place. To the west of the beach the gneiss is finely foliated, but the dip is almost vertical, while on the east headland the rock is much more massive and dips landwards. Hence in neither case are conditions particularly conducive to cliffing. The cliff line at present is eroding only very slowly, presenting the typical convex appearance of a Lewisian gneiss cliff line, although in the past, possibly during a period of higher sea level, much more active cliffing must have occurred. The age of the cliff-line is evidenced by the plug of glacial till in the geos to the west of the beach, indicating that the cliff-line must have been cut in pre-glacial times.

The present slow progress of marine erosion on the neighbouring cliffs must mean that the beach material has not been derived from this source. Some of the material, which is mainly a fine sand, may be derived from the removal of till plugs in the cliff forms but this would only be a minor source. Another possible source of limited quantities of material is from the three streams which debouch onto the beach. In their lower courses where they flow through narrow, steeply graded valleys containing pockets of glacial till and deeply weathered rock, they will be able to acquire considerable loads of material which they can supply to the beach, and at the extreme west of the beach the stream has built up a sizeable fan of material. There is evidence that the regime of the streams may be liable to quite large fluctuations, and when they are in spate the rates of supply of material will be correspondingly augmented. However, material coarser than sand, derived from either marine or fluvial erosion, is almost entirely lacking on the beach, although in the past, during a period of higher sea level, a raised shingle bar was thrown across the mouth of the Allt Chailgeag at the east end of the beach. This raised shingle bar is roughly at the same height as the one at Sangobeg and would have been formed during the same period.

The convex shape of the beach plan, a reflection of the protective influence of Eilean Hoan, means that the $^{c}/_{p}$ ratio cannot be calculated but the beach appears to be fairly stable with no marked tendency to change

its orientation. The beach functions together with the Traigh na h-Uamhag beach as a single unit, with a certain amount of seasonal movement of sand around the headland of Rubha na Griosaich which separates the two beaches.

The high cliff-line behind the beaches prevents the blowing of sand far inland. In the minor re-entrants, such as that of the stream following the Clais Charnach, accumulation has occurred in the form of broad dune-like ridges which probably rest on raised shingle bars. Most of these ridges are slightly undercut by waves on their seaward edges, and wind on their other sides, but marram is actively colonising the undercut faces. Behind these small marram clad dune ridges, a reverse gradient slopes against the cliff-line and the vegetation is a typical machair sward. On the cliffs a thin layer of blown sand has accumulated, the thickness and inland extent of which are inversely proportional to the cliff height. Where the cliff is vertical or near vertical practically no sand accumulation has occurred at all, and nowhere does the sand thickness seem sufficient for erosion scars to form although soil creep is in operation. That several periods of sand blow, separated by long periods of stability, have occurred in the past is shown in a section above the raised shingle bar near the outlet of Allt Chailgeag. Here a vertical section through the blown sand overlying the shingle shows alternations of peat and organic material with fresh sand lacking in humus content. At present, although fresh sand occupies the topmost layer, there appears to be a period of relative stability with little sand accumulation occurring.

Most of the cliff slope behind the beach is strongly influenced by blown sand and salt spray, although the influence begins to die out above the road. On the near vertical sections of the cliff, where frost shattering occasionally rives off large blocks, birches and other forms of shrubby growth have obtained a foothold, while on sheltered sections bracken has established dominance.

The area is intensively grazed by sheep, and rabbits are numerous, but there are no signs of biotic damage. Vehicular access onto the beach area is impossible because of the steep cliff between the beach and the road, and in any case there is no flat ground on which caravanning could take place. Thus the pattern of use is that of the short visit. The beach, being an attractive one close to but some way below the road draws many tourists on the course of their journey along the north coast. Most of the visits are, however, very brief; the tourists just walk down to the beach from their cars, go a short distance along it and then return. Little damage results from such tourist use and there are no conservational reasons for suggesting that the type of use should be modified. If greatly increased numbers of tourists visited the beach, the descent down to it might have to be improved and litter disposal facilities provided, but at the present level of use there appear to be no problems.

5.13 Coldbackie

Morphology (Figure 8.10), Vegetation (Figure 6.11), Exposure (Figure 5a), Photograph 8.

The small embayment of Coldbackie is on the east side of the Kyle of Tongue where a small strip of basal Old Red Sandstone conglomerate is found resting on the Moine metamorphic country rock. The conglomerate forms the greater part of the 1,009ft high Coldbackie hill which dominates the landscape of this local region. Along the coast, however, the conglomerate has formed a zone of relatively easy excavation and the beach and dune area occupies this re-entrant in the coastal outline. Metamorphic rocks form the largely fossil cliff-line which rises to over 250ft O.D. and which forms the southern boundary of the area. To the north the conglomerate and the succeeding metamorphic beds form a series of benches stretching northeastwards towards the now little used rock-girt harbour of Skullomie.

At its greatest extent the beach is 600 yards long and 120 yards deep with a flat upper beach and relatively steep gradient of 4° between mid and low tide marks. The beach materials consist of medium-textured, reddish sand which is at least partly derived from the erosion by both marine and fluvial action on the Old Red Sandstone beds. Rock reefs occur on the east side of the beach and can cause wave action to build temporary berms which retain relatively deep rock and sand pools. The essential dynamic nature of this beach area and its sheltering hooked-spit is best represented in the rapidly changing beach forms of the more exposed easterly corner of the bay. The great sandspit and beach form a coastal entity created by the interplay of strong ebb-tide currents flowing northeastwards out of the Kyle, refracted and subdued wave action from the northwest quarter which has passed round or sometimes over the sand bars linking the Rabbit Island group and the stronger north to south running waves coming in from the open fetch to the west of Eilean nan Ròn. The beach and spit complex of Coldbackie are, in effect, the outermost coastline of the sediment-filled Kyle of Tongue.

With this abundant source of sand, winds from the northerly quarter have piled sand into the depression offered by the conglomerate beds. A depression which contained topographic diversity in the form of an old conglomerate cliff-line surmounted by an 80ft bench covered by glacial till. On top of this cliff, stream discharge and scree from the amphitheatre on the north side of the Coldbackie hill mass have formed a 20–30° sloping apron of drift. With this mantle of debris a stream is incised, and it reaches the sand dune area over a waterfall created by the abandoned marine cliff already described.

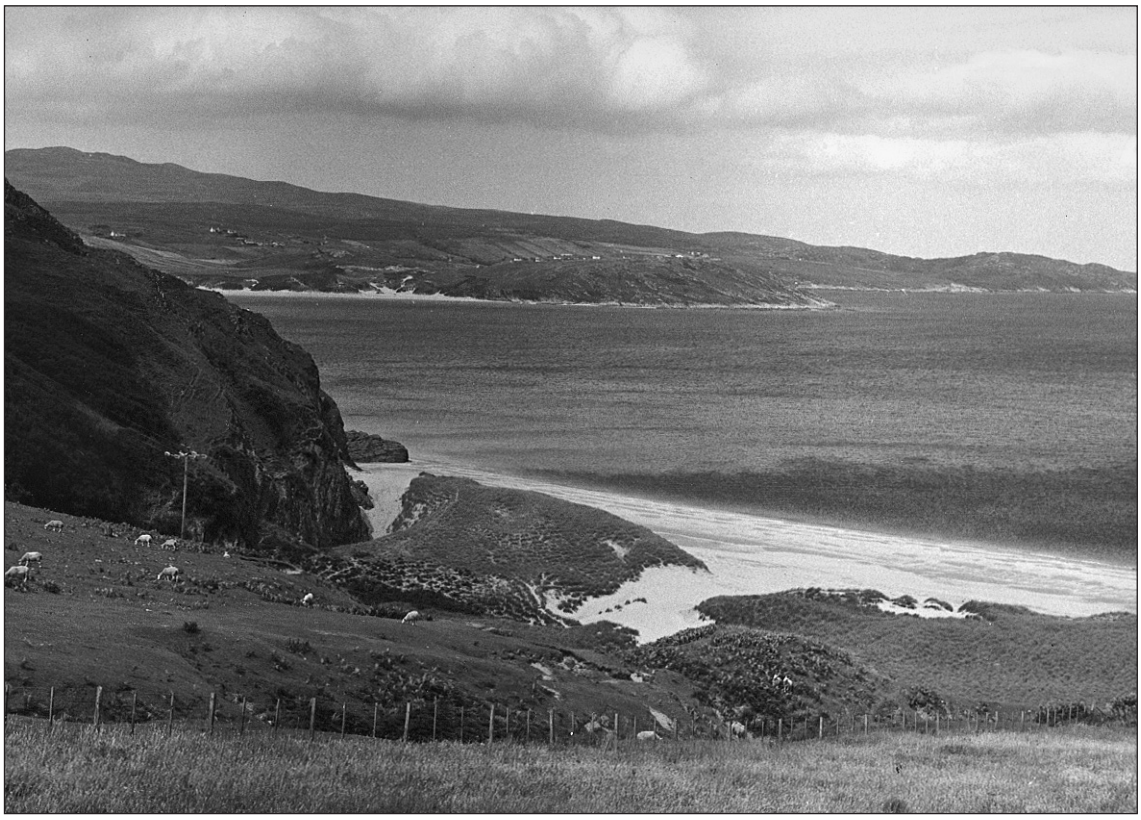
The reception surface for incoming sand is thus highly variable and a broken relief pattern is found. Vigorous, marram and *agropyron* clad dunes rise to over 40ft O.D. in the western side of the area where the sand has been piled against the sheer cliff wall of the metamorphic hill mass. These dunes are dissected by deep blowouts trending in a general northwest-southeast direction and thus emphasising the rôle of the cliff face in channelling local wind patterns. Some sand spreads onto the cliff face and enriches the till capping of the upper slopes. Because of its inaccessibility rich vegetation forms are found here, and there is considerable tree and shrub cover. The sand also spreads onto the steep slope stretching up to the line of the main road. A machair sward, subject to bracken invasion, has formed in this relatively thin sand cover.

The main or central area is occupied by one major transverse dune, two blowouts, several corridors of bare sand and a marshy, boulder-floored area between the old cliff-line and the dune area where the stream, already described, seeps into the sandy floor of the depression.

The third area affected by sand drift is the gently-sloping, till-covered area east of the stream which stretches from the edge of both the fossil and active cliff edges southwards to the line of the main road. Apart for the machair-covered bevel of the cliff edge the area is well-fenced and still under arable agriculture. The sand cover of this area has been mixed into the soil by ploughing but appears to be very thin and fades out rapidly upslope.

The area is still grazed by sheep but there was no sign of rabbits. There were no caravans, since the steep slope down from the main road which is 200ft above the beach precludes any access, and only one or two tents pitched on the dunes. Nevertheless the human modification of this area is considerable. Car parking is provided for about twenty cars along the side of the main road and the day-to-day use of the beach is relatively heavy. Unfortunately by the nature of the terrain only one access path is used and the steepness of the slope, particularly where the path goes over what is in effect the old cliff-line, has led to the development of incised sand corridors. These sand-paths are difficult to ascend so considerable branching of the track has occurred in the steeper sections. Moreover the material beneath the soil is unconsolidated drift and this access track is undoubtedly a potential axis for gully erosion or even a landslip. At the bottom of the slope the configuration and height of the dunes cause visitors to take only two paths to the beach and both of these are now corridors of deep soft sand.

Coldbackie poses a problem for conservation. The beach, the cliffs and caves have an intrinsic attractiveness and a large carrying capacity which is readily apparent to anyone driving along the main road from Tongue to Bettyhill. The beach area is also well sheltered from the west, south and east (Figure 5). The access to this large beach area, however, can only be over a steep, constricted and potentially unstable zone. In the absence of any feasible alternative to the present path the only solution would appear to be the strengthening of the present path, perhaps even with the introduction of steps and thorough maintenance of the existing drainage system to avoid the possible danger of gullying or slope wash.



Photograph 8 Coldbackie – General view of upper slope, dunes and beach.

5.14 Torrisdale Bay

Morphology (Figures 8.11a,b,c), Vegetation (Figure 6.13), Photograph 9.

The Torrisdale Bay area contains every landscape element which brings complexity or interest to the coastline of Sutherland. Strong structural elements, extensive ice action, meltwater deposition, changing sea levels and vigorous dune building and sand drift combine to make this area a bewildering mélange of landform and landscape elements and the area has rightly been made a Nature Reserve. Yet the macro-patterns of the area are simple – a high glacially scoured flat-topped ridge of ancient metamorphic rock jutting northwards into the sea and flanked by major river depressions which have served as important corridors of outwash deposition during the closing stages of the Ice Age – and fringing these a great apron of beach and sand hills which climb to the top of the ridge itself.

The central ridge of Druim Chuibhe dominates the area and consists of strongly foliated Moine schists with a wedge of injection complex of pelitic schist forming the west side of the Naver River. Ice has scoured and etched the rock in a south-north direction leaving the relatively flat ridge-top broken into a series of ridges and marshy hollows. Numerous erratic boulders some of which are over 20ft high dot the ridge crest and lower slopes. Glacial debris also forms the greater part of the screes found on all sides of the ridge. Equally important, however, are a series of parallel fractures running in an east-west direction which tend to subdivide the ridge into a series of steps descending northwards. On the sides of the ridge these weaknesses seem to have been enhanced by the plucking action of ice passage so that there is an alternation of bare relatively smooth rock with a shattered face pointing northwards and shallow depressions into which the screes and bare sand have been funnelled. The most significant of these lines of structural weakness has been used by the stream flowing out of Loch Drium an Dùin and eastwards into the lower Naver. This narrow steep valley has had an important rôle in channelling sand drift up onto the ridge top. Similar metamorphic rocks to those on Druim Chuibhe form the valley sides of the Borgie and right bank of the Naver. The two headlands which stretch out almost a mile on either side of the bay are also formed of high resistance metamorphics of the Moine series.

Meltwater in the latter stages of the Ice Age also provided the great aprons of sand and gravel which dominate the lower Borgie and Naver valleys. At least three terrace levels corresponding to different sea levels can be picked out on the east side of the lower Naver valley. Two similar platforms of sand and gravel form extensive surfaces at between 50–70ft O.D. on the east side of the Borgie estuary and the west side of the Naver. Sand dunes and machair have developed over and against these outwash features. The Naver "terrace" contains several archaeological sites of great importance including cairns, hut circles and cist burials and is of greater extent than the analogous Borgie "terrace". The Naver "terrace" has been modified by ice-contact and local meltwater action so that it has an undulating surface: the Borgie "terrace" is relatively flat. Remnants of outwash gravels and shingle are also found on the northwest side of Druim Chuibhe but like the main terraces have been partially removed by higher sea levels in late- and post-glacial times. These large terrace features and other outwash phenomena in both the Borgie and Naver valleys indicate the enormous volume of sediment which came out of the two river valleys towards the close of the Ice Age. This has undoubtedly provided the sand and shingle for the huge inter-tidal expanse of beach. The curious feature of the morphology of the bay is the relative absence of shingle forms since shingle is the dominant grade of material in the outwash and kame terraces of both valleys.

Torrisdale Bay is the fusion of two great estuarine zones of deposition – the Borgie and the Naver. The scale of the beach is vast: at one point the distance from dune to low water mark is over ½ mile with more than half this distance being a dry sand area above the reach of high tide. With a $^{C}/_{p}$ index of 4.1 the beach is quite stable but shows a slight tendency to rotate clockwise, ie material from the "Naver-side" of the beach moves to the west. With such a wide inter-tidal zone and exposure to northerly winds the sand is driven up the valleys and onto the sides of the ridge in the form of dunes and machair. Sand also forms the main material of the areas of saltmarsh shown in Figures 8.11a and 8.11b. Most of these saltmarsh areas are old and eroding, often revealing a basement of water-worn shingle which might suggest that shingle could be found at some depth beneath the present beach. The largest area of saltmarsh occurs at Torrisdale on the west side of the Borgie estuary, where it forms a protective platform for the narrow strips of raised beach, arable croft land fringing the west side of the bay.

The main area of deposition on the west side of the bay occurs in the angle between the outwash terrace and Druim Chuibhe. A large area of vigorous marram dunes form an approximately triangular area characterised by very irregular topography and steep-sided sand hills and dunes. No preferred orientation is evident and the few deflation areas are also aligned in arbitrary directions. Shingle is exposed at the base of some erosion scars and appears to be a lag deposit from the outwash terrace. The sand from this area has spilled over the retaining stone wall onto the outwash platform and irregular, hummocky, marram-clad ground extends for up to 50 yards southwards before giving way to smooth machair. This continuous tableland of machair extends over most of the terrace but thins out in a south and southeasterly direction. More spectacular are the climbing dunes and cones of scree and bare sand that are found on the north and west facing slopes of Druim Chuibhe. In the northwest corner these are particularly impressive and merge into the 30–40ft high coastal dunes.

The drainage of the outwash platform, the ridge slope and part of the dune area follows a channel running along the foot of the ridge. The water soaks into the sand dune area but re-emerges as seepage outlets along the north coast as shown in Figure 11a.

The northernmost limit of the outwash feature in the Naver valley reaches the same point as the Borgie terrace and the features are clearly contemporary. The angle between terrace edge and the rocky side of Druim Chuibhe contains a much smaller area of dunes and sandhills. There are lines of dunes, including embryo dunes, and high sandhills which are pressed against the ridgefoot zone but the volume of sand available has been distributed in other ways – as discontinuous dunes on the outwash platform and as deep sand deposits on the sides and top of Druim Chuibhe.

Climbing dunes, open screes of sand and rock debris and patches of heath (including *Dryas*) or machair developed on sand are found on the north, northeast and east facing slopes of the ridge especially where depressions in the rock structure has permitted deeper accumulation. Possibly northerly winds have a freer access here to Druim Chuibhe since the ridge has an orientation which is more N.N.W.–S.S.E. at this point; possibly too the Naver estuary is, or has been, more unstable and the stage of development is more advanced than is the situation on the Borgie side of the ridge; nevertheless the contrasting morphology of the two sides of the ridge is one of the outstanding features of the area.

Sand influence extends to 360ft O.D. on the east side of the ridge and as shown on Figure 11b erosion scars and terraces are features of the ridge top. This is ecologically extremely important as it is one of the

main factors giving floristic richness to the Nature Reserve, which in this area includes associations of *Dryas*, *Calluna*, *Empetrum*, *Carex* and *Juniper* along with rarer individual species of which *Primula Scotica* is best known. An important source of sand drift, however, is east to west via the valley formed by the stream flowing out of Lochan Druim an Dùin. This corridor allows sand to spread into the south-north depressions already described. This valley axis is characterised by deep sand and debris screes especially on the northern side where visitors scramble up to the relatively well preserved broch on its rock spur.

Much of the beach sand is carried against and over the outwash terrace. As shown in Figure 11b the pattern of sand hillocks is discontinuous although many of the dunes and hillocks follow depression axes in the outwash surface which are relics of kettle holes and local meltwater drainage. The largest of these depressions is an old ice-contact slope between the terrace and the base of the rock ridge. Bare gravel and stone areas colonised by open maritime heath separate the marram hillocks and the contrast between the stable machair grazing of the analogous Borgie terrace is striking. The frequency of cairns, cist burials, grave mounds and other archaeological features may offer a partial explanation in terms of antiquity of use, but it is necessary to use caution with this hypothesis since similar undiscovered sites may well lie beneath the machair and dunes of the Borgie terrace.

The remaining sand dune area of the Torrisdale Bay area lies more than 1½ miles from the low water mark of the bay although it is close to tidal water in the Naver river. This complex of sandhills and machair at Invernaver is shown in Figure 11c and is separated from the area previously described by a wide tidal sand flat bordered on the west by a discontinuous apron of shingle, machair, dunes and sand-covered talus slopes. The sand hills and undulating machair are developed on ridges of fluvio-glacial material. The blown sand is of similar composition to the sand of Borgie (dunes) or Naver (dunes), ie median diameters Invernaver 268 microns, Borgie 303 microns, Naver 254 microns, but is better sorted than the two exposed dune areas. In spite of its distance from the primary source the soil is quite deep reaching an estimated 5–6ft on the lower slopes of the fluvio-giacial hills. Flatter machair is found where a small stream flowing out of Loch Mer reaches the tidal flat but even here with the stability created by a high water table erosion is evident.

Unlike the Borgie and Naver dune and terrace areas Invernaver is subject to severe human modification. The land use, as in the entire area of the reserve, is common grazing with sheep being the main stock animal. All three areas are grazed by sheep and cattle owned by crofters of the Invernaver township although the land is owned by two estate interests – the Countess of Sutherland west of the watershed and the Nagus estate to the east. The Borgie terrace which is also known as Melvich park is enclosed by stone dykes and appears to have been under arable cultivation but, according to local information, has been in sheep and cattle grazing for the last thirty years.

Although there is no camping or caravanning nearby or in the Reserve, Invernaver suffers from being the only road or track access to the Reserve and the machair is heavily tracked. In summer more than twelve cars have been seen parked on the small central machair area. Car parking provision would appear to be an important improvement in this area. Even with a car park access to the beach or the features of interest, as for example the archaeological sites, requires a long walk over exposed tidal flats. A footbridge could easily be built across the lower Naver using one of the islands in the river but whether this is in the best interests of the Nature Reserve is a debatable point and would probably conflict with the fishing interests on this well-known salmon and sea trout river.

Photograph 9 Torrisdale Bay – Lower Naver. Outwash terrace, discontinous sand dunes, east-facing side of Druim Chuibhe with bare sand and scree fans, climbing dunes, ice-stripped rock exposures. Stream from Loch Druim an Dùin above.

5.15 Farr Bay

Morphology (Figure 8.12), Vegetation (Appendix 3), Photograph 10.

Farr beach occupies a northwest facing, U-shaped bay which is strongly confined by schist, gneiss and injection complex cliffs. The east cliff is generally higher and vertical cliffs are found rather than the stepped cliffs and abrasion platforms of the west side. The structural trend is the same as the axis of the bay, ie southeast to northwest but important subsidiary depressions occur transversely to the main structure. The most important of these is the shallow depression leading to Clerkhill township and the inland depression now followed by the main road from Bettyhill to Armadale. The rear wall of the beach, dune- and machair-filled depression is formed by the ancient cliff of Creag Clachan which is formed of tightly foliated schist dipping here at an estimated angle of 75° or more.

Three elements fill this initially simple structural depression; a ridge of glacial till, a complex dune and machair system and a beach, and a fourth landscape element is added with the considerable spread of blown sand onto and over the 250ft high ridge which forms the western rim of the area. Glaciation, meltwater, changing sea levels, and the meander and flood of the Clachan Burn all combine with the variety of materials available to create a subtly complex array of depositional and erosional forms.

The beach, although having a $^{c}/_{p}$ index of 6.0 and a slight tendency to clockwise rotation, is characterised by its width – it is 450 yards long and 300 yards wide from foredune to low water mark. The beach gradient is therefore very low and were it not for the convergence of the wave fronts to produce some of the finest surf conditions on the north coast little wave derived activity would disturb the beach area. Activity is largely confined to the northeast corner where a bank of shingle is being reworked and to the southwest corner where the interplay of river water and wave action has cleared the veneer of beach sand to reveal a shingle and cobble basement. At both ends of the beach, therefore, there is evidence of intermittent erosion and movement of materials. The central part of the beach also bears signs of undercutting along the dune face but this can only occur rarely when high tides and suitable winds coincide.

The dune and machair complex is dominated by an eastwest asymmetric ridge of till reaching to over 60ft O.D. and terminating at the footbridge where an undercut riverbank section shows how thin the veneer of wind-blown sand is at this point. The backslope of this ridge slopes at 5–7° southwards to the Clachan Burn. Similar sloping machair is found south of the burn. Much of this area near the outlet of the burn and especially in the arable machair ground northwest of the footbridge lies below the 25ft contour and is backed by an old cliff-line of the late- or post-glacial higher sea level. Other "levels" are found at between 50–60ft O.D. and a platform at between 70–90ft is found cut in drift-covered rock on either side of the bay. Neither of the latter levels are as clear as the "25ft" level but are representative of the greater problem of the distribution of these raised shoreline features which can be noted from the Kyle of Tongue eastwards.

The north-facing slope of the central till ridge is steep and often identified by lines of blowouts and deflation scars since the underlying spine of till has formed an effective limit to wind erosion. The lower ground to the north is an undulating mosaic of old and new deflation and depositional sand features. It is generally covered in vigorous marram tussocks as is the lower level to the north and west which is the zone of present-day dune growth and activity. These dunes form a continuous front to the beach and are generally over 20ft high except in the northeast corner where the relief patterns are more subdued. The zone of dune and

general sand deposition is thus wedge-shaped, and it is suggested that the present topography may well be related to earlier times when the Clachan Burn took a more northerly course to the sea, possibly at a time of higher sea level, before being diverted to its present southerly route between the till ridge and the cliff of Creag Clachan.

Although the focus of drainage of a wide region is into Farr Bay, and the beach is for a large part wet even at low tide, sand blowing appears to be still active. Much of the mobile sand, however, is being reworked from earlier landforms and a considerable proportion of this is carried westwards onto the side of the "Clerkhill Ridge". The entire side of this ridge and much of the crest is covered in relatively deep sand. Moreover, two corridors, the one already described leading to Clerkhill township and a similar one further east, have allowed considerable volumes of sand to spread not only onto the crest of the ridge where it rests directly on ice-roughened and frequently shattered bedrock but down the north side into a valley-like depression where it finally fades out in the marshy valley bottom. This large area of short grass machair sward is heavily grazed by sheep, cattle and rabbits, and with the presence of steep slopes it is hardly surprising that Farr Bay repeats the pattern of having most erosion and instability on the *margins* of the dune and beach area proper. Large erosion scars and slips expose the rock basement over wide areas of the hillside, trench-like corridors occupy minor depressions in the metamorphic structure and together these provide dry fine sand (192 microns) for further sand spread, not it must be stressed as dramatic dunes or waves that choke ditches and block roads but as imperceptible additions to the veneer of sand in areas further inland.

Thus if we add the area of gently sloping machair spreading south-eastwards along the middle course of the Clachan Burn on the south side of the main road, the total area influenced by blown sand is far greater than is first realised, being an estimated ten times the total area of the beach.

Being near the important settlement of Bettyhill (which has a moderately large caravan and camp site in the village) and the main trunk road (A836), Farr Bay is relatively well known and used. At present, however, it can only be reached via a footpath (with stiles) and footbridge. The beach can also be reached from Clerkhill and it is here that future erosion might be expected since cars can be parked directly on the thin ridge-crest machair at the top of the downhill path to the north corner of the beach. Another access point for vehicles is found east of the village of Clachan but this is fenced off and marked private. This latter point exemplifies an additional feature of the area – land tenure. The area around Clerkhill and much of the side of the hill is common grazing for Clerkhill and Crask but the lower ground near the beach is divided up and fenced by several "owners". Some of the land, especially south of the till ridge is arable and a proportion is enclosed as Church ground or for owners living in the township of Clachan. The unusual tenure system of the area is a result of its being glebe land owned by the Church of Scotland. The trustees of the Church have let out parts of the area to three or four tenants. As previously described the area is used for agricultural purposes but it is not clear if the terms of rental exclude other forms of commercial development.

Farr Bay is thus mainly stable, well-used in both recreational and agricultural senses but bearing in mind its location and potential accessibility this most attractive sheltered beach and surf-swept bay could become an area requiring far-sighted planning decisions sometime in the future.

Photograph 10 Farr Bay

5.16 Armadale Bay

Morphology (Figure 8.13), Vegetation (Figure 6.12), Exposure (Figure 5a).

Armadale beach occupies the head of a fairly deep, narrow bay on an east-west section of the coast just to the west of Strathy Point. The beach is about 600 yards long with an inter-tidal zone of about 200 yards and a very wide upper beach above high water mark of nearly 100 yards. The underlying rock is Moine schist, with metamorphosed igneous intrusions (epidiorites and horneblende schists) forming either flank of the bay. There is a strong north-south orientation in the rock structures and the bay is excavated along the strike of the rock. The bay depression does not extend far inland in the form of an open river valley as happens further east in the Strathy and Strath Halladale valleys, but instead bifurcates into two fairly short, narrow valleys. The more easterly of the two valleys opening out into the bay is occupied by the Armadale Burn, and is a very narrow, steep-sided trench. The present stream occupying the trench seems quite incapable of carving such a valley, and there is strong evidence that glacial meltwater was initially responsible. The valley to the west is more open and gently sloping, but here again there is evidence that the whole valley was not excavated by Allt Beag, and again meltwater is likely to have operated. At the mouths of these meltwater valleys, a large fan or delta of coarse fluvio-glacial material was deposited, when the sea level stood well above its present level. This raised delta of sand, gravel and cobbles has been extremely important in the evolution of the subsequent beach. The material extends along both sides of the bay as well as occurring in a dissected fan at the head of the bay. On the flanks, the gravels lie on a rock-cut platform a few feet above present high water mark, which may represent a marine abrasion platform cut during a period of higher sea level.

The bay is very open to the north, and exposure to winds and waves from this quarter is severe. However, there is little evidence of erosion occurring at present on the rock sections of the bay sides. The waves and their splash have, however, been able to remove part of the fluvio-glacial deposits from the flanks of the bay, leaving a rather complex cliff profile in which there is a low vertical or convex rock section, a narrow horizontal ledge or platform, and then a steeply sloping upper part cut in gravel. Higher sea levels may be partially responsible for this two-storey appearance, but there is evidence to suggest that some evolution is occurring at the present day. Some undercutting does occur on the dune front during northerly gales and spring tides, but the beach is reasonably stable although the $^{c}/_{p}$ ratio is rather high at 10.0. The strong northerly exposure is likely to make the beach liable to considerable seasonal and other short-term fluctuations. There is a very slight tendency for the beach to rotate in a clockwise direction, seeking a more easterly component in its orientation.

The limited amount of marine erosion proceeding on the nearby cliffs means that little sediment is being supplied to the beach from this source. Greater quantities are likely to come from the two streams debouching at the bayhead, especially from their lower stretches where they cut down through the fluvio-glacial deposits. Most of the beach material is medium sand, except at the mouths of the streams where there are spreads of shingle representing reworked material from the coarser fraction of the gravels. A third, and very important source is in the bay immediately offshore, where the finer fractions of the fluvio-glacial load carried by the meltwater would have been deposited. These fine sediments have been washed ashore to form the beach and blown sand areas, but there still appears to be large quantities of sand in the bay, so that there does not appear to be any imminent danger of the supply of material ceasing.

Blown sand has accumulated against the steep front edge of the raised delta in the form of a dune ridge, which lies against the delta front in the middle of the beach, but is some distance seaward from it at either end. The marram-clad ridge is fairly stable with little evidence of blowout formation. In the area between the dune ridge and the delta front towards either flank of the bay, hummocky sand hills have accumulated with a few blowouts mostly orientated north-south. The sand thins out very rapidly against the terrace edge of the delta whose top is practically free of sand. On the east side of the bay, however, winds from the northwest quarter have distributed sand onto bare rocky slopes, and here a type of thin machair occurs. The thickness of sand varies with the micro-relief of the rock surface but is nowhere more than 2–3ft. As is the case in so many other areas where a thin veneer of blown sand has collected, scarring has developed and erosion is at the present proceeding rapidly. As elsewhere, aspect, depth of sand, and underlying rock topography all influence the rates and types of erosion, but there is a general pattern in so far as most of the blowouts, which are mainly fairly small, are linear features orientated in a northwest to southeast direction. In some places, however, this orientation is complicated by small second generation blowouts trending off the linear northwest to southeast features in a southwest to northeast orientation, suggesting that winds from the southwest as well as from the northeast can be damaging. A third type of blowout is the small crescentic type with the concave face pointing upwind, generally in a southwest direction, and it is possible that this crescentic type may evolve in time into the linear type by unequal rates of movement of the two horns of the crescent.

Although the area of blown sand over rock is extensively scarred by blowouts it is stressed that only a relatively small area of such sand does occur. The direction of sand blow is confined to a narrow sector, and the sand does not spread out widely. Also it is emphasised that little erosion is occurring on the dune area of deep sand.

The vegetation pattern is the typical one illustrated in Figure 4, with machair swards occurring on the limited areas of blown sand. The cliff-top vegetation is modified by salt spray, while on the top of the raised delta the natural vegetation has been replaced through cultivation.

The blown sand area to the southeast of the beach is part of the common grazing of Lednagullin township, which carries a heavy stock of sheep. Indeed the opinion was expressed locally that overgrazing was practised, and it is quite possible that there may be a connection between the overgrazing and erosional scarring. Rabbits are also numerous, and undoubtedly contribute to erosion. Behind the beach and dune ridge the land, which is part of Armadale Farm, and is not under crofting tenure, is cultivated, while on the west side of the beach is the croft land of Armadale township.

Tourist use of the beach is restricted by the difficulty of access from the main north coast road which runs a ¼ mile or more back from the beach. Vehicular access is not possible, so that there has been no development of caravanning and hence no environmental damage has resulted from this source. Pedestrian access is not particularly easy, as there is no obvious short track from road to beach. The little use that is carried on, however, falls into the pattern of the very short visit, during which little damage occurs. Indeed in terms of tourist use Armadale beach is practically untouched. However, the beach is reasonably stable in terms of both marine and aeolian processes, and should be sufficiently resilient to withstand very much more use than is the case at present. Certainly the beach would appear to be one admirably suited to small scale recreational use, and perhaps in time might prove an attractive alternative if Farr Bay to the west were to become over-utilised.

5.17 Strathy Bay

Morphology (Figure 8.14), Vegetation (Figure 6.14), Exposure (Figure 5a), Photograph 11.

Strathy Bay occupies the angle between the north pointing promontory of Strathy Point and an east-west trending section of the north coast. The beach is nearly half a mile long and 300 yards wide, with an upper beach between high water mark and the dune front tapering towards the east. The mouth of the River Strathy is at the west side of the bayhead, and the river plays an important rôle in the morphology and supply of material to the beach.

The west headland of Strathy Point, which protrudes from the east-west trend of the coastline like a giant groyne, is composed of granitoid rocks incorporated in the Moine schist complex, while the more subdued eastern headland is composed of the Caithness Flags of the Old Red Sandstone. The latter beds dip northwards at an angle of about 30°, while the strike of the rocks of the western headland is north-south. The valley of the River Strathy, which trenches the low plateau of the north coastlands, follows this north-south strike, and has been excavated along the contact of the metamorphic and sedimentary rocks. The solid rock of both headlands are overlain by glacial deposits. On the west side, glacial till overlies benches cut in the rock, while to the east there is a layer of fluvio-glacial outwash material 100ft or more thick. This very thick, flat-topped, outwash deposit merges on its landward side into a massive ridge of sand and gravel more than 200ft high. This ridge trends across the valley, forcing the River Strathy outlet to the west, and is parallel to the shore. It is very important in the overall beach morphology, and in particular it serves as a barrier tending to limit sand blow inland. These glacial and fluvio-glacial deposits in all probability once continued offshore, where the ground appears to be sandy. The bottom is gently shelving, the five fathom line being nearly ½ mile out.

The bay and beach are not strongly exposed except from the northeast quarter, which is fully open to winds and waves, the latter augmented by refraction round Strathy Point. Marine erosion is largely confined to the eastern headland, which is not only more open but is also composed of more easily eroded sandstone. In addition to clear evidence of erosion during periods of higher sea level, especially in the raised abrasion platform on which the outwash deposits rest and in cliff notches above present high water mark, there are signs that the cliffs are still receding, although perhaps at a slower pace than formerly. Above the rock section of the cliff profile is the more gently sloping section cut in the outwash gravels. Here slumping and other subaerial mass movement processes are responsible for the ultimate morphology of the cliff rather than directly marine processes.

In addition to the strong coastal slope cut in the outwash deposits, there are also deep, steep-sided valleys eroded by minor streams. On the west headland where the rock type is less conducive to marine erosion, there is less evidence of the present-day occurrence of cliffing, and the coastal slopes are largely vegetated and indeed veneered with till in places. Evidence of past erosion is testified by a till-covered bench at about 60ft O.D., and a much lower abrasion platform, on which rests occasional lag boulders, a few feet above high water mark. Although the cliffs to the west of the beach are no longer being cut by the waves, they are still evolving under slow mass movements of till and weathered material. There is also some evidence of gullying by streams. The contrast in terms of marine erosion between east and west headlands of the beach are continued on the beach itself. On the east side of the beach, there is very marked undercutting of the dune front, the upper beach being very narrow. On the west side of the beach, towards the mouth of the

river, there is no sign of undercutting, but accretion is taking place instead. This would suggest that the beach is tending to rotate in a clockwise direction, seeking a greater easterly component in its orientation, although there is no confirmation of this in the form of asymmetry of the plan of the inter-tidal zone. Indeed the normal curvature of the low water line is almost totally lacking, so that the $^{c}/_{p}$ ratio is very high at 48.33. Usually this would mean that the beach was very unstable, but it is suggested that the rapid deposition of material near low water mark was responsible and that consequently the $^{c}/_{p}$ ratio in this instance gave a misleadingly high index.

The sand of the beach tends to be rather coarser than on many of the beaches investigated but the shell content is still fairly high. Material is supplied from a number of sources, including the erosion of the sandstone cliffs to the east and from the slumping of glacial and fluvio-glacial deposits on the upper parts of the cliffs. In addition to these sources, a supply of material is to be expected from the offshore deposits, and also from the River Strathy. Shingle is generally lacking on the beach except at the mouth of the river, suggesting that the river is responsible for the supply of the large calibre beach material. The finer fractions of the river's load will be incorporated with material from the other sources and distributed across the beach by marine action. That there is a copious supply of sediment to the beach is testified by the sand banks and berms on the beach, suggesting that accretion is occurring at the present day. It seems likely, however, that in the past coarser calibre material was more important than at present, for blowouts between the frontal dune ridge and the fluvio-glacial ridge have exposed traces of a shingle platform, perhaps constructed during a slightly higher sea level on which the dune complex rests.

As Figure 8.14 indicates, the dune complex consists of two separate dune ridges parallel to each other. The inland, and older, ridge hinges onto a point on the fluvio-glacial ridge, and probably signifies an early phase in the infilling of the bayhead. The larger and younger dune ridge which is evolving at the present day is hinged not onto the fluvio-glacial ridge backing the beach, but instead on the cliff to the east side of the bay. This outer ridge is still growing rapidly westwards, although as has been mentioned it is subject to undercutting at its eastern end. This pattern of accretion and erosion is in accord with a general westerly drift of material which the overall coastal configuration might suggest.

A number of small blowouts are developing near the western end of the ridge, but they appear to be of purely natural origin and are not likely to prove dangerous. Larger circular blowouts have developed on the inland slope of the eastern part of the ridge but again there is no evidence that the erosion is other than a natural phenomenon. However, at the extreme east end of the ridge, and in the blown sand occupying a deep, dry gully followed by a footpath from the cliff-top, a number of linear blowouts have formed, which may be connected with pedestrian use although the evidence is inconclusive. Inland from the dune ridges, blown sand has been distributed on the fluvio-glacial ridge up to and across the summit. The ridge has exerted an important influence on the pattern of sand blow inland by tending to confine the spread of sand. A few small blowouts occur on the sand on the ridge summit, but they do not seem dangerous nor do they appear to be associated with tourist activity. To the west of the end of the fluvio-glacial ridge, blown sand extends inland in the form of flat machair overlying shingle but soon gives way to a marshy zone along the river banks.

The vegetation sequence differs from that depicted in the model in Figure 4 in the absence of a wide flat machair zone. A very large part of the area affected by blown sand is under machair type communities containing marram, rather than the typical short machair sward. Inland from the area affected by blown sand

fresh water marsh communities occupy the floodplain of the lower part of the river, while on the cliffs the vegetation is modified by salt spray action. Although most of the sand-affected area is common grazing, the quality of grazing is not high since marram is so abundant, and no grazing animals were observed during the investigation.

Vehicular access is possible as far as a point to the west of the graveyard on a col in the ridge summit. Here the road terminates in a patch of machair where there are some signs of picnicking but otherwise little evidence of tourist use. The nature of the terrain precludes large scale development of caravanning. Some pedestrian use is made of the beach, access being possible both by a path leading from the road end and one leading down to the eastern side of the beach. However, although the beach area is visible from the main north coast road, the means of access is not immediately apparent, and is in fact off a very minor road. Hence there is little attraction for tourists to break their journey along the coast and visit the beach, and it is thus very little used. From the viewpoint of physical conservation there is no reason for precluding more intensive use, since the beach area seems to be reasonably stable. If such intensified use is to take place, however, much better signposting will be required on the minor road leading to the beach, and also better turning and parking facilities.

Photograph 11 Strathy – General view of "graveyard ridge", flood plain, dune platform, climbing dunes and beach. Note depth of drift on backing cliffs.

5.18 Melvich

Morphology (Figure 8.15), Vegetation (Figure 6.15), Exposure (Figure 5a).

Melvich beach forms the terminus of the prominent south to north corridor of Strath Halladale. The beach is almost semi-circular in outline with a low $^{c}/_{p}$ index of 3.2. The total length from Portskerra pier in the northwest to the outlet of the River Halladale is approximately 750 yards long and up to 180 yards wide. The beach is very stable being strongly supported by the granitic rocks of the western headland and the flagstone of the Old Red Sandstone on the east. The pier is built where the boulder beach of the west side of the bay meets the prominent rock abrasion platform which terminates in Sgeir Ruadh although within this boulder beach, occasional bedrock exposures are found near high water mark. On the eastern side, however, the inter-tidal rock abrasion platform with its characteristic "stepped" appearance forms the east bank of the tidal discharge section of the river. The unconsolidated beach therefore faces northeast towards the maximum fetch whereas the bay itself faces due north and is simply a continuation of the depression axis of the strath.

Apart from lithological differences the east and west cliffs are quite different in so far as the 100ft cliffs of the eastern side are cut in very deep glacial till and are fossil whereas the east cliffs only attain 100ft O.D. on the most prominent northerly exposure and are cut partly in bedrock and partly in till. The easterly cliffs are clearly more subject to marine action in spite of the protective barrier of the abrasion platform.

The cobble beach contains very large water-rounded and sub-angular boulders derived from the erosion which led to the – retreat of the cliff. Similar ill-sorted morainic material can be seen in the severe slips and gullies which are found especially in the southwest angle of the cliff. Some of these gullies appear to be related to the presence of field drains but if the present is a guide to the past then the retreat of the cliff line would appear to be due to sub-aerial rather than marine processes.

The implication of the distribution of the beach materials is that the drift is west to east and the boulder beach is a residual feature whereas the sand and, to lesser extent, shingle beach to the east is the dynamic component which has built out a spit across the river exit and forced its channel hard against the east cliff. This beach also contains fine examples of beach cusps which are again features of considerable beach activity on a local scale. The river must also play a part in the supply of sediment to the beach as its bed and banks are of gravel and shingle of a similar calibre to the shingle found at the distal end of the spit. Further upstream the river flows between terraces up to 100ft thick of fluvio-glacial sands, gravels and shingles now exploited by the construction industries and these materials would undoubtedly be carried to the sea in the past. Strath Halladale is similar to Strathnaver in so far as it was a major corridor for the deposition and passage of outwash materials in enormous quantities. The thicknesses of glacially and fluvio-glacially derived sands and gravels in the general region are quite spectacular and it is surprising that so little of the material has been reworked to form beach and dune sand, but as shown in Figure 3 it would appear that great banks of material still lie offshore beneath the reach of effective wave transport.

The morphology of the area contains other problems in the existence and shape of the river bed where it meanders sharply to the west at the sand-covered spur on which is sited the large residence of Bighouse. No evidence is readily available to suggest whether or not this is a raised shingle spit pointing *west*, or a rock-cored bar across the river.

Upstream from this bend the river is still tidal and its bed is wide, shingle and sand floored, and edged with marshy flats which give way in turn to low banks representing either flood stages of the river or banks constructed when the river was flowing in adjustment to a higher sea level. On the west bank great terraces of sloping fluvio-glacial deposits form the arable croft land of Melvich township but these fade out northwards under an encroaching mantle of blown sand.

The area of sand dunes and machair is relatively small but of high relief: most of the dunes and sandhills reach to over 50ft O.D. Over most of the area the beach is accreting and vigorous marram is the characteristic vegetation. The area has a vegetation pattern in general which closely resembles the type profile of Figure 4. There are, however, two major areas of bare sand which have completely breached the dune barrier. Some attempt has been made to seal these openings by the relatively expensive means of erecting fences and covering the bare sand areas with brushwood. It is too early to judge the success of these efforts but some sand accumulation has occurred against the fences as is indicated by the slope arrows on Figure 8.15. The north-south trend of the sandhills is important, however, and is repeated throughout the rest of the area and clearly represents the strong funnelling of winds from the north by the deep penetration of the bay axis and from the south by the corridor of Strath Halladale.

A conspicuous break of slope runs within the sandhill complex in a generally northwest to southeast direction and begins at the first elbow-bend of the river. Although covered by variable depths of sand it appears to be composed of till and/or outwash materials. It has an important effect on the morphology of the machair and machair/croft land transition zone but its origin may well be due to its having been the ancient left bank of the Halladale at a time when its mouth was much further to the west and at a time before the build-up in sand dunes.

To the west of the river the area was once under grazing which gave way to fenced-off sheep folds and arable or grazing fields in the southwest part of the sloping machair. But there is little or no evidence of grazing today. It is difficult to assess the influence of the estate in this area. The footbridge appears to be maintained by the owners of Bighouse who also appear to be responsible for the attempts to consolidate the areas where sand-drift is occurring. The evidence available suggests that all the area west of the river is under crofting tenure whereas the area east of the river belongs to the estate and was formerly a farm, the large rectangular fields of which can still be seen rising to head dyke at approximately 150ft O.D. on the east side of the bay. In general, however, the area is more or less inaccessible to vehicles approaching from either side of the river. Pedestrian access is relatively easy as there is a footpath from the north end of the village of Melvich which leads downslope, skirts the southern edge of the dunes and reaches the footbridge. Another path reaches the dunes via the edge of the west cliffs. Both these paths involve a relatively long walk and are far from conspicuous. Accordingly the area is very little used. There is no evidence whatsoever of camping or caravanning in the immediate area. Day-to-day use is very slight in spite of the considerable scenic attraction of the area and its relative proximity to the population centre of Dounreay-Thurso. Vehicle access can still be had to the pier at Portskerra but from there it is a difficult ½ mile scramble across the boulder beach to the sand. In general, therefore, this coastal area consisting not only of Melvich Bay, but the peninsula of Portskerra and the magnificent cliff-girt embayment to the west is truly unspoilt.

6. General conclusions on some problems of the development of beach areas in north and west Sutherland

Although the foregoing has emphasised the diversity of conditions in the north and west Sutherland beaches it is possible to make a few general observations particularly on the part played by tourism in the modification of the physical environment.

The intensity and amount of use varies enormously as does the degree of damage. No single cause can be evoked for sand dune or machair erosion. Change in amount and rate of supply of sand to the beach, natural cyclical changes in sand dune evolution, short-term weather changes, overgrazing by stock or natural fauna and tourist use all contribute to erosion.

Of these factors tourist use and grazing can be controlled: the others only to a minor extent. The most serious problems occur where caravanning and car access is practicable. Pedestrian access seems to cause little erosion. Achmelvich, Clachtoll and to a lesser extent Stoer, Clashnessie, Sheigra and Sango Bay all have erosion features which may be related to the driving of vehicles across potentially unstable sand surfaces. Once an erosion feature begins, any form of tourist access aggravates the problem and inhibits the natural growth of stabilising vegetation although the initial impetus may well have been caused by natural processes.

Of the areas studied only Achmelvich is a licensed site for 36 caravans, yet even early in the season, July, more than 65 caravans were on the immediate beach and machair area. The Achmelvich area epitomises the problem as it clearly represents a situation where the demand for space exceeds the physical and conservational capacities of the area.

The solution is not simple and one can only suggest the alternatives. Less developed sites in other areas as for example the southern end of Balnakeil peninsula could be extended for both "stopping" and residential caravan owners and thereby release the pressure on the small number of areas used today. This wider dispersal of caravanning and camping would require not only prohibitions or limitations on the use of some areas, but also better publicity for some of the other beach areas on the north coast, in particular those which are less accessible and less well-known. There is no doubt, however, that all existing and proposed caravan sites should be controlled especially with regard to amenity conservation and the provision of standard facilities. Moreover, the provision of metalled roads would control the worst aspects of vehicle access onto machair and dune surfaces.

It is perhaps easy to criticise caravan and camping sites as being the root cause of the physical deterioration of the beach area and frequently such criticisms are coloured by aesthetic appearances rather than by real evidence. Other factors operating over a longer term, such as excessive stocking of sheep and cattle on the common grazings and the unchecked spread of rabbit warrens particularly on the sloping margins or transitional zones of the machair, are equally responsible for environmental damage. Both these latter factors are severely reduced at present but evidence from elsewhere indicates that rabbits can develop natural resistance to myxamatosis and spread back into cleared areas.

Throughout the survey the authors were aware that these issues were only part of the greater problem of tourist development in Highland Britain generally. Peculiar Scottish problems of crofting tenure, estate interests, depopulation and inadequate communications and services along with a pernicious dearth of

capital form the constant background to such a study. Nevertheless, the authors regard the beaches, dunes and machairs of north and west Sutherland as a potential resource which will only become worthwhile if connected to material or aesthetic advantage for the community. It is a question of conservational development rather than preservation. Nor should any developments be tightly planned for almost by definition these are the areas where people wish to escape from a regimented existence.

Achmelvich and Clachtoll are beyond stabilisation and can only be restored by the injection of large amounts of capital and if this has to be done then it could produce in the end a functional, attractive caravan and camping site. Many areas such as Scourie, Sheigra, and Clashnessie have limitations which can only be overcome by siting the caravans, chalets and campsites well away from the respective beaches. Undeveloped beaches as on the north coast east of Loch Eriboll could respond and assimilate moderately controlled and imaginative development. The Durness group of beaches will require balanced development as described in the appropriate chapters. Above all the solitude and unspoilt attraction of beaches such as Sandwood should be carefully conserved as a special form of resource management.

7. The Beaches of Sutherland: Supplement

In 1969 the Countryside Commission for Scotland invited the Department of Geography, University of Aberdeen, to undertake a survey of 'certain selected beaches' on the north and west coasts of Sutherland. Later similar surveys were extended to other parts of the Highlands and Islands, and eventually in 1975 a general review of all the beaches in the Highlands and Islands was initiated. In carrying out this review, the surveyors revisited the Sutherland beaches which had been surveyed in 1969, and also visited the beaches not included in that survey. The notes contained in this supplement were recorded during the 1975 visits.

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1. Traigh Shourie (Handa)
2. Traigh na Teampuill (Handa)
3. Kervaig Bay
4. Kyle of Durness
5. Keoldale
6. Melness
7. Talmine
8. Strathan

Traigh Shourie (Handa) NC 140475

General setting

Traigh Shourie is the name applied to the two small beaches occupying the embayment in the central part of the south shore of Handa. The beaches lie at either end of this embayment, and like the embayment itself, are strongly influenced by the south-west trending strike of the Torridonian Sandstone beds which underlie the island. Both beach complexes, but particularly the west one, contain only small quantities of sand, and much of the shore in the embayment is of sandstone reefs.

Beaches

Small quantities of sand have accumulated against strike controlled ribs of sandstone which define the east and west ends of the embayment. The west beach is wedge-shaped, with the narrow end (only 10–15m wide) towards the seawards. The edges of the wedge are marked by flat reefs of sandstone. The beach is very thin, and is interrupted by rock outcrops and by immobile cobbles. Its backshore is approximately 20m wide, but the upper part of it consists of a 10m fringe of storm cobbles.

The east beach is longer, thicker and less interrupted by cobbles and outcrops. Its east flank is a low sandstone headland, under 10m in height, while at its west end it lies against low flat reefs. The sand, of mixed organic and mineral origin, has a lime content of over 70% and has been built up into a beach with a gradient of approximately 6°. The backshore is 30m wide, with a fringe of storm cobbes occupying the highest 5m. The total length of the two short beaches is just over 100m.

Coastal edge and dunes

Most of the coastal edge, with the exception of a short stretch behind the west beach, is neutral. At the west end of the west beach, the edge takes the form of a cobble ridge, while further to the east this gives way to a low sand cliff (less than 1m in height) which overlies the ridge. Behind the east beach, the coastal edge is much higher, rising to 10m. Again, however, it is stable and neutral, having the form of a sloping Marram bank, at the toe of which there is a low sand cliff, less than 1m in height. The coastal edge is here broken by 3 linear blow outs, of which the branching, easternmost one is the most active. The other two are smaller, shallower and less active.

These blow outs are cut into rather formless areas of grey dunes, averaging 10m in height but rising to over 20m in squat, conical forms. Some circular cauldrons, indicative of a higher degree of activity in the dunes in the past, are still clearly visible but seem to be rapidly healing over. Eastward dipping beds of sandstone protrude through the dunes in places, and their alignment, parallel to the main direction of sand blow, has been a potent influence in the dune morphology.

The dunes behind the east beach (except at the redeposition tips of the blow outs) are maturely vegetated in sparse Marram over a thick mossy turf, through which a large amount of ragwort protrudes. The sward is punctuated by numerous rabbit burrows and scrapes, which threaten the long-term stability of the dunes.

There are no dunes behind the small west beach; the rockcored bank behind the east end of the beach is sand faced and carries sparse Marram with much ragwort.

Machair

The machairs are undistinguished, except for their degree of infestation by rabbits and ragwort. The small area of machair behind the west beach is particularly severely over-grazed, especially by rabbits, and much of it has already been deflated so that it exists now only as a thin veneer over the sandstone. The deflation faces are aligned parallel to the southwest wind and to the grain of the rock.

The machair behind the east beach and dunes is larger, and indeed coalesces with the Traigh Teampuill machair. For the most part it is thin and undulating, and its morphology is strongly influenced by the underlying rock. Some deflation faces are still visible, but most are much less active than formerly.

Vegetation, land use and ecological considerations

Old cultivation traces are clearly visible on the landward flanks of the machairs, but agricultural use is now confined to sheep grazings. The blown sand areas, with their lime enrichment and relatively free drainage compared with the rest of the peat-clad island stand out as green islands of potentially richer grazing. In the absence of herding, sheep tend to concentrate their grazing on the machair areas, as also do rabbits. Consequently, symptoms of overgrazing such as the breaking of the sward and invasion by ragwort have become very noticeable, and both machairs have a rather degraded appearance. The stench of rabbit droppings is strong, and detracts from the attractiveness of the machair as much as rabbit grazing does from its agricultural value.

As well as being a RSPB reserve, Handa is a Site of Special Scientific Interest, mainly on the basis of its birdlife but also partially because of the coastal cliff scenery. The beaches themselves are of little interest scientifically, (except for the outcrop of aeolianite near the west end of the east beach).

Recreational use

The well-marked footpath from which visitors to Handa are asked not to stray passes through both machairs and within short distances of the beaches. Despite the considerable number of visitors to the island (up to 50 per day at the height of the season) few people visit the beaches, which are of very modest attractiveness. There are some signs of trampling on the path, but since it leads through machair rather than dunes, and since it is transverse to the prevailing wind direction, there is little likelihood of significant erosional damage.

Recommendations

The main problem is that of rabbit infestation especially on the west machair. Although rabbit populations are probably now past their peak, the present level is sufficiently high to detract both from the stability and from the attractiveness of the area. It is therefore strongly recommended that the rabbits should be exterminated. To give the machair a chance to recover from its severly degraded condition, it is also recommended that sheep should if possible be excluded from the machairs (particularly from the west machair) for a few years.

If these suggestions were adopted, it could confidently be asserted that the stability, attractiveness and long term agricultural value of the machairs would be greatly improved.

Traigh Na Teampuill (Handa) NC 146475

General setting

The beach complex lies at the south-east corner of Handa, and ties a northeast-southwest trending ridge of Torridonian Grit to the rest of the island. The isthmus between the ridge and the rest of the island consists of a rock-walled corridor partially filled with sand, and blown sand also extends up the steep island slope to the north-west. Beaches occupy either end of the isthmus; the one at the north end is the larger, and is the point of landing for the passenger ferry which serves the Island.

Beaches

The beaches at either end of the isthmus differ in exposure, physiographic base, and amount of sand. The small beach at the south end is set deep in the embayment defined by strike-controlled rock ridges, and is afforded additional protection by the skerries near the west flank of the embayment. The sheltered situation of the beach is reflected in its low gradient of just under 4°. The beach appears to be thin; the gravelly sand (lime content 31%) of which it is composed is interrupted in places by lag cobbles. The backshore is approximately 10m wide.

The north beach takes the form of a sweeping arc tying the north end of the grit ridge to the mainland of Handa. The beach is much thicker and better nourished (mainly by sand arrived from local Torridonian Sandstone) than the south beach. Despite the shorter fetch than that to which the south beach is exposed, the beach suffers higher energy conditions, because it lacks the protection of long rocky headlands. The gradient of the convexo-concave profile exceeded 7° at the time of visit and probably frequently exceeds this value during adverse weather and marine conditions.

The backshore is assymetrical, varying from 10m at the north end to over 30m at the south end. Shingle is virtually absent from the beach.

Coastal edge and dunes

The north-west and east sides of the beach are defined by low rock cliffs against which no blown sand has accumulated. Behind the central part of the beach, the coastal edge takes the form of low dunes, whose axes are not parallel to high water mark, as is usual, but instead are aligned in a northeast-southwest direction, parallel to the rock strike. These low dune ridges, averaging 2m in height, occupy the whole width of the corridor between the grit ridge and the rest of the island, and are extremely fragile forms. The elongated depressions between the low ridges are mostly of bare sand, partly because of trampling damage along the path between the landing point and the day shelter, which is the focal point for visitors to the island.

A long, residual dune feature also overlaps the northwest side of the through corridor between the north and south beaches. This dune has been severely deflated on the hill side, and a shell midden and temple site have been exposed. The north end of this residual dune feature is a parabola-shaped blow out facing due south.

Erosion has worked back some distance from the dune-machair contact, and several deflation faces are visible on the hill side behind the beach complex. The hill machair is mostly thin, and, like the machair of Traigh Shourie, with which it coalesces, its topography is very largely that of the underlying rock. Erosional activity appears to be dying out on the machair area, and also to some extent on the dune straddling the northwest edge of the rock corridor. Within the corridor itself, however, activity remains very high, and the dunes are extremely fragile.

Vegetation, land use and scientific considerations

Vegetation follows the usually beach-complex pattern, with active yellow Marram dunes in the through corridor where there is still sand movement, fixed grey marram on the flanks of this corridor, merging into machair which in turn dies out against wet moor. The main feature of note in the vegetation is the abundance of ragwort, which is probably indicative of severe grazing pressure from sheep and rabbits. Part of the transitional machair is enclosed by a stone dyke, and was possibly used as a lambing park in the past; signs of overgrazing, however, are by no means confined to this enclosure. The beach complex itself is of no great scientific interest, although Handa is a Site of Special Scientific Interest primarily on account of its rich bird life. There is some archaeological interest in the beach complex, both in the remains of the sand-entombed temple from which the beach takes its name, and in the shell middens that have been exposed by wind erosion.

The whole island is grazed by sheep at present, and in the absence of intensive herding, they tend to graze selectively on the drier and less acid blown sand areas, as also do numerous rabbits.

Recreational use

The beach complex functions as a transit zone through which people move between the boat-landing point and the day shelter, to which a notice on the beach directs all visitors to proceed. The stretch between the north beach and the day shelter is by far the most used path on Handa since, unlike paths of the rest of the island, traffic moves in both directions. It is most unfortunate that the section of path carrying the heaviest traffic (probably about 50 return journeys per day during the height of the season) should also be the most fragile. Signs of trampling damage are very clear, especially where the path descends from the machair to the dunes at a point approximately 150m northeast of the day shelter. Although most of the wet parts of the round-island path are traversed by duckboards or stepping stones, no management is apparent where the path leads through the dunes.

In addition to serving as a through route, the dune area is also used for picnicking and sunbathing while waiting for the boat. It therefore receives considerable usage despite its insular setting; indeed its level of usage is higher than on many mainland beaches.

Recommendations

The attractiveness and stability of the beach complex could be improved by the twin measures of reducing grazing and trampling damage. The first priority is probably to reduce permanently the rabbit population, and if possible to exclude sheep, at least for a number of years, from the lower seaward part of the dunes and machair.

Ideally an alternative route should be sought between the landing beach and the day shelter. Any alternative route, however, would be steeper than the existing one, and there would probably be resistance to its use. If the existing route is to be maintained, however, it is desirable to provide some means of protection in the most trampled areas, and also to construct simple steps at the point where the path descends from the machair to the dunes.

Kervaig Bay NC 290727

General setting

Kervaig Bay is a spectacular but rarely visited bay on the north coast some 3km east of Cape Wrath. The cliff coastline in which the bay is set is composed of Lewisian Gneiss to the west, with characteristically rounded cliff profiles rising to 80m, while to the east higher cliffs, rising to 200m, have been cut in horizontally bedded Torridonian Sandstone. Two valleys carrying sizeable streams issue at the bay; the east valley follows a major faultline separating the gneiss from the sandstone. Despite some shelter from two small skerries, the beach is very exposed to the northwest, and is a typical high-energy unit, set in coastal scenery of some grandeur.

Beach

The beach, composed of sand with a lime content of around 50%, extends to 250m in length, and its exposed situation is reflected in the steepness of its profile. The steepness, combined with the apparent irregularity of the nearshore zone and the turbulence generated around the stream mouth and the skerries, mean that the beach is most unsafe for bathing. At the time of study, during a long spell of fine weather, a large berm had built up, with a distinct reverse gradient of 2°. This berm was defined on its landward margin by the stream which enters the east side of the bay, and which had been deflected westwards across the beach to share the outlet of the west stream. The wet sand and standing water along this stream course act as an effective barrier for movement of sand landwards. Behind this wet channel there is a backshore of approximately 30m, leading up to a cobble ridge. This ridge increases in height from west to east (from 2-4m above high water mark, and is composed of cobbles of Torridonian Sandstone mixed with gneiss at the west end). The ridge is flat topped, and extends to about 25m in width. Formerly, much of this ridge was probably overlain by dunes or machair, which have subsequently been stripped off by wind erosion. Partial recolonisation has occurred, but the vegetation is still very discontinuous.

Coastal edge, dunes and machair.

A feature of Kervaig Bay is the absence of a clearly defined coastal edge separating the beach from the machair. The front edge of the machair has retreated several tens of metres under attack from wind erosion, and an undulating area of humified blown sand, probably representing a former soil surface, leads from the fresh deflation edges of the machair to the cobble ridge. Machair retreat has been greatest at the east end, where exposure to the northwest is greatest, and has occurred along a face originally parallel to high water mark. This long face is broken by a few short deflation fingers almost at right angles to it. The machair edge is mostly under 1m in height, but is still very active. A large part of the machair, together with any dune zone which may once have existed, have already been removed, and there is no evidence that the erosion has been checked.

The Kervaig machair is unusual in two respects. Firstly, erosion appears to have been solely from the coastal edge backwards: there is no sign of significant blow outs having been initiated in the landward part of the machair and then extended seawards. Secondly, the deflation floor exposed on the retreat of the machair scarp is highly irregular; it is not defined by the water table or by a level shingle floor. As has been stated, the deflation floor takes the form of a surface of humified sand. This surface is highly irregular and is probably associated with old habitations and refuse deposits.

The area of the machair to the landward of the erosion edge is triangular in shape, tapering to a narrow point at the west end, and becoming wider eastwards. At the west end, it terminates sharply against a hill slope which is but thinly veneered with blown sand. Further east, the machair thins out more gradually along the valley of the stream entering the east side of the bay. Most of the machair is thin and undulating; its topography probably reflects that of the underlying rock and drift.

Dynamic relationships

The beach complex is typical of high energy conditions, with a steep profile, a massive cobble ridge, and a severely eroded machair. Streams strongly influence the geomorphology of the beach, both as agents of sediment supply and as factors influencing the relief of the beach complex. The beach complex appears to be at an advanced stage in development; the dune zone has been completely removed and erosion has extended well back into the machair. The rate of erosion may well now be slowing down, but it is unlikely that it will be halted while a significant area of uneroded machair remains.

Vegetation

Backshore pioneers, other than some seasonal growth of Sea Rocket, are almost completely absent from the sandy beach. But on the sand-filled intertices on the cobble ridge which has been progressively exposed as the machair has been eroded an unusual development has occurred in the form of colonisation by Sand Couch. Towards the inner (landward) parts of this cobble ridge, the Sand Couch is joined by silverweed, and eventually the whole area may be expected to revegetate. The deflated area behind the Sand Couch shows little signs of grassing over yet, despite the locally high humus content of the sand. When colonisation begins, however, it will probably be rapid.

Landwards of the machair edge, most of the machair is enclosed in fences, and has at least partially been improved. Its floristic composition is undistinguished.

Land use

Kervaig Bay lies in part of Balnakeil sheep farm, and the whole area of the machair is given over to sheep grazing. Formerly, a shepherd occupied the now abandoned house which overlooks the beach, and parks are enclosed by still-maintained fences on the machair and its immediate environs. Sheep are now normally excluded from these parks in summer, and thus the vegetation is able to recover from grazing at other times. The abundance of ragwort in the machair suggests that overgrazing has occurred in the recent past. There are few rabbits.

The abandoned house, together with the severely eroded machair combine to lend an air of dereliction to the landwards part of the beach complex. This air is emphasized by the remains of rude shelters of cobbles and rusting corrugated iron near the machair edge. It is believed that these shelters were constructed by campers from a local adventure school. Refuse from the now abandoned house, and a considerable quantity of broken glass, further detract from the attractiveness of the area landwards of the cobble ridge. Indeed the untidiness is very disappointing, particularly in such a remote and isolated beach. In contrast, however, the view seawards is magnificent, with high but contrasting cliffs on either side of the beach, clean beach sand and complex and ever changing wave action.

Recommendations

The usual means of access to Kervaig Bay is by the Cape Wrath minibus service, which runs between the Kyle of Durness ferry and Cape Wrath lighthouse. The beach is not visible from the road used by this minibus, and in any case most of the bus passengers wish to visit the Cape. Therefore visits to the beach are most infrequent, and recreational use is extremely slight. Under such circumstances, it is unlikely that Kervaig Bay will figure highly in priorities for recreational management. Nevertheless if it is contended that a number of 'wilderness' type beaches should be maintained for recreational use as well as more intensively used ones, then efforts should be made to conserve the quality of the environment in such beaches. Little can be done to control the machair erosion (short of heavy expenditure), but the removal of debris from the zone between the beach and machair would be very welcome. Perhaps such a project could be carried out by a body such as the conservation corps or by an adventure school.

Kyle of Durness (Cape Wrath Hotel to Balnakeil Bay) NC 370675

General setting

The Kyle of Durness is a shallow, sand-encumbered inlet characterised by a number of right-angled bends which reflect the influence of fault lines in its configuration. Wide sandflats are exposed at low tide, but active beaches, where the sand can dry out sufficiently to be able to be blown, are few and small, some very small cliff-foot beaches occur on the west side of the Kyle near Achiemore, but the main concentration is on the east side between Keoldale and Balnakeil. Here a number of small, short beaches have accumulated against the edges of the low limestone plateau which forms the shore of the firth, and very extensive but mainly thin blown sand deposits have been laid down on the limestone plateau itself.

Beaches

There are three main beaches, with a total length of approximately 500m, together with some smaller sand patches such as the one near Eilean Dubh at the north-west tip of the area.

The most northerly of the main beaches is strongly influenced by an outcrop of east-dipping limestone which forms the lower part of the beach. The upper beach is broken by spreads of boulders, and the backshore is only 10m wide. The beach is thin and wet, and is poorly nourished, there being little continuing supply of sand to it. The middle beach is distinguished by the probably temporary growth of a sand spit out from the point where the coastal edge of the limestone plateau changes direction. This spit extends to about 200m in length and its surface is very gently sloping. Behind it lies an area of wet sand built into a series of ridges and runnels. At its root, the spit is hinged onto a 10m limestone cliff, and south of the root a line of jagged low (2m) east dipping limestone reefs occur just below high water mark, impounding some tidal pools. The backshore behind this beach is very narrow, and is broken by rock outcrops in places. The southernmost beach consists only of a small area of mobile sand which has accumulated at the cliff-foot near the point where the coastline changes direction from northeast/southwest to northwest/southeast.

In all three beaches, the quantity of mobile sand is very small; the beach forms only a narrow fringe between the wet sandflats and the limestone plateau edge. Although the area of inter-tidal sandflats in the Kyle of Durness is large (approximately 65ha in the section currently under discussion) the effective area, from the viewpoint of supply of sand for dune and machair building, is very much lower.

Coastal edge and dunes

Most of the east shore of the lower part of the Kyle of Durness takes the form of low limestone cliffs, rarely exceeding 10m in height. Behind the beach sectors, rock frequently outcrops, but on the two more northerly beaches a sand cliff, as high as 15m in places, has been cut. This erosional nature of the coastal edge, where it consists of sand, is in keeping with the thin wet nature of the beaches; there is clearly an inadequate supply of sand for dune-building at present.

The main development of dunes is behind the central beach. Here a foredune ridge, averaging between 12 and 15m in height, has been built up parallel to high water mark. Both the seawards face, which is partially cliffed, and the landward slope are steep and the crestline is sharp. At the north end of this beach, a large blow out has been cut into the dune, and together with its redeposition zone, gives an appearance

of a parbolic, south facing dune. The dune ridge is also broken by the stream which issues via a dune slack towards the north end of the beach.

Behind the north beach, a maturely vegetated Marram-clad ridge has been built up against the limestone scarp which approaches closely to the shore at this point. This ridge, which averages 8m in height, is not a free-standing dune, but is simply composed of blown sand banked against a steep slope.

The cliff-foot south beach has given rise to a number of small climbing dunes. Much of the 8–10m cliff which lies behind the beach is sand free, but on the 20–30° slope above the cliff several small dune forms are visible and appear both to be mobile and growing.

Machair

The machair is very extensive, but is mainly only 1–2m in thickness, and it has been almost completely deflated over large areas. The main supply point appears to have been from near the southwest shore, rather than from the west coast where most of the present beaches lie. The machair appears to be almost completely fossil, in the sense that there is now no continuing sand supply. Topographical influences from the underlying limestone have controlled both the main deposition areas, and also the areas where deflation has been most vigorous. Most of the higher parts of the undulating limestone plateau have now been swept clear of their machair capping, and limestone pavement has been exposed in places. The depressions, on the other hand, still carry machair, whose edges take the form of erosion faces which are now mostly grassed over. Also the more northerly part of the machair, where the blown sand thins out, has been much less affected by deflation and the machair there is relatively intact except for a few deflation fingers which are almost invariably fixed.

Small areas of bare sand are still visible around some of the deflation edges, but activity is very slight. Comparison of 1946 air photographs with the present day shape, size and position of the erosion faces shows that there has been very little change, and the scars are probably kept fresh only by sheep rubbing.

Dynamic relationships

The blown sand accumulations on the east shore of the Kyle of Durness are complex both in their form and in their evolution. The present day sandflats in the Kyle would not have given rise to the extensive dune and machair area, and it may be that the main period of formation was during a phase of slightly lower sea level, when the sand flats would have dried out more frequently and more completely, thus enabling sand to blow landwards.

Vegetation

A great diverity of habitats is presented by the combination of a limestone substrate and blown sand deposits, and the area is of very high ecological interest. *Dryas octapetala* is widespread, usually occurring on sloping surfaces with only a thin veneer of blown sand, while *Primula Scotica* also grows towards the northwest corner of the area. The existence of dune slacks and a range of hydrological conditions in the machair adds to the ecological interest of the area, while the habitat diversity is enhanced by the existence of a plantation of pine in the central part of the limestone plateau. The area lies within a Site of Special Scientific Interest defined on botanical and geological grounds.

Land use

Most of the area between the Cape Wrath Hotel and Balnakeil Bay is part of the Keoldale sheep stock club, owned by DAFS and managed collectively by Durness crofters. There is no evidence that agricultural use is detracting from the stability of the beach complex.

Recreational use is very slight. Although there are no physical barriers to pedestrian access, vehicular access is not possible. The beaches are not visible from the A838, and only a few visitors penetrate from either the Balnakeil end or from the road end at the Kyle of Durness ferry.

Recommendations

The little used beaches offer a complement to the heavily used beaches around Durness, and should be retained in their present form. No new management measures are considered necessary at this time.