

No. 85

COASTAL SHINGLE IN GREAT BRITAIN

A preliminary review

by

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ISSN 0952-4355

ACKNOWLEDGEMENTS

The authors are grateful to Chris Jordan for typing the manuscript, Ian Culley and Ian Agnew for drawing the diagrams, and the many students of Girton College, Cambridge, who have assisted in fieldwork.

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NCC COASTAL ECOLOGY RESEARCH PROGRAMME

The Coastal Ecology Branch of the Chief Scientists Directorate was established in August 1979. One of the functions of the branch was to co-ordinate a programme of research and survey in the field of terrestrial coastal conservation. To this end a research programme has been developed with four main aims:

1. To describe the size, location and quality of the main coastal habitats in Great Britain (saltmarshes, sand-dunes, vegetated shingle, sea-cliffs, strandlines, 'reclaimed' land and maritime islands).
2. To assess the impact of major development projects on sites of national importance for nature conservation.
3. To provide guidance on the management of the main coastal habitats for nature conservation.
4. To investigate the role of physical and biological processes in the maintenance of natural and semi-natural coastal habitats.

The results are disseminated in a variety of Nature Conservancy Council publications.

- a. CSD Contract reports: limited numbers with specialist interests are produced. Copies are usually prepared by the contractor and made available as a Chief Scientist Directorate Report in microfiche through the Nature Conservancy Council's Information and Library service.
- b. Contract survey reports
- c. Research & survey in nature conservation
- d. Focus on nature conservation

If you would like any further information on this report or on the research programme please contact Dr Doody in Peterborough.

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General Introduction to the Study

Shingle borders about one third of the 19,000 km of shoreline in Great Britain. Some 3500 km or 20% of the beaches at (MHW) Mean High Water are almost pure shingle. (This is a massive natural nature conservation resource which has been little studied.) At a small number of locations, a series of beaches have been deposited on top or against each other to form sometimes massive areas of shingle, such as Dungeness. In recognition of the importance of these areas for the conservation of specialist plants, animals and vegetation types, a national review of these structures and their vegetation is being undertaken. This work forms part of a Great Britain wide review of coastal vegetation of sand dunes, saltmarshes and sea cliffs currently being undertaken through the Nature Conservancy Councils' (NCC) Research Programme. This report outlines the current status of vegetated shingle in Great Britain and provides a preliminary assessment of a survey being undertaken at Girton College, Cambridge under contract to the Chief Scientist Directorate of the NCC.

Because of the size of Dungeness and the complexity of the vegetation a detailed survey has been undertaken as part of the Great Britain wide review. However, this is under separate contract with Royal Holloway and Bedford New Colleges (Ferry and Lodge, 1990). At the same time a parallel study of the invertebrates has been carried out in order to provide a comprehensive picture of the interest in this important site.

Origin of Shingle

In the south of Britain much of the shingle is composed of flint (Steers, 1926), derived originally from the chalk but latterly eroded from glacial cliffs by the action of the sea. This flint has been deposited either directly on to the foreshore, or has been reworked via offshore banks. In other cases the sediments (especially larger cobbles and boulders) have been brought to the coastline by rivers draining nearby highland areas. A third source is glacial material from the seabed including considerable quantities of erratics.

The shingle from any of these locations may form a beach in situ or may be transported along the coast by longshore drift to form a beach where conditions are suitable. The predominantly southward-pointing shingle spits of the east coast of England illustrate this latter point very well. Many of the shingle beaches were formed in early post-glacial times and have acted as skeletons

upon which sand-dunes have subsequently been built. This is seen at Blakeney Point and Scolt Head Island on the North Norfolk coast (Steers, 1971). An examination of the coasts of Britain (Steers, 1964, 1973) shows that many of the smaller shingle features are intimately associated with neighbouring marsh or sand formations and are thus ecologically intermediate in habitat. Others are entirely separate and display characteristic shingle ecology. On mainland Europe shingle is a frequent component of the Baltic shores (Eklund, 1924, 1931; Warming, 1906; Böcher, 1969) and the Atlantic coast of France (Gehu & Gehu, 1959; Gehu 1960a, b, c, 1963). Elsewhere in the world shingle is a rare coastal habitat, only being found commonly in Japan (Nakanishi, 1982, 1984) and New Zealand (Simpson, 1976). The geomorphic development and environmental conditions of the British shingle structures are reviewed in Randall (1989), along with a general description of the vegetation present. It is estimated that there are approximately 4200 ha of shingle structures with some form of vegetation. The 65 or so major sites represent the most significant areas from a nature conservation point of view.

Fig. 1 shows the major areas of British shingle. Concentrations of shingle sites occur in several areas though long stretches of coastline are virtually devoid of shingle structures. The main locations are to be found in the Northern Isles, the Moray Firth, East Anglia, the English Channel, the Britol Channel, North Wales, the Lake District, the Solway Firth and the Clyde estuary. In other areas shingle may occur as a fringing beach but rarely develops into a more extensive structure with semi-stable or stable shingle.

SHINGLE HABITATS

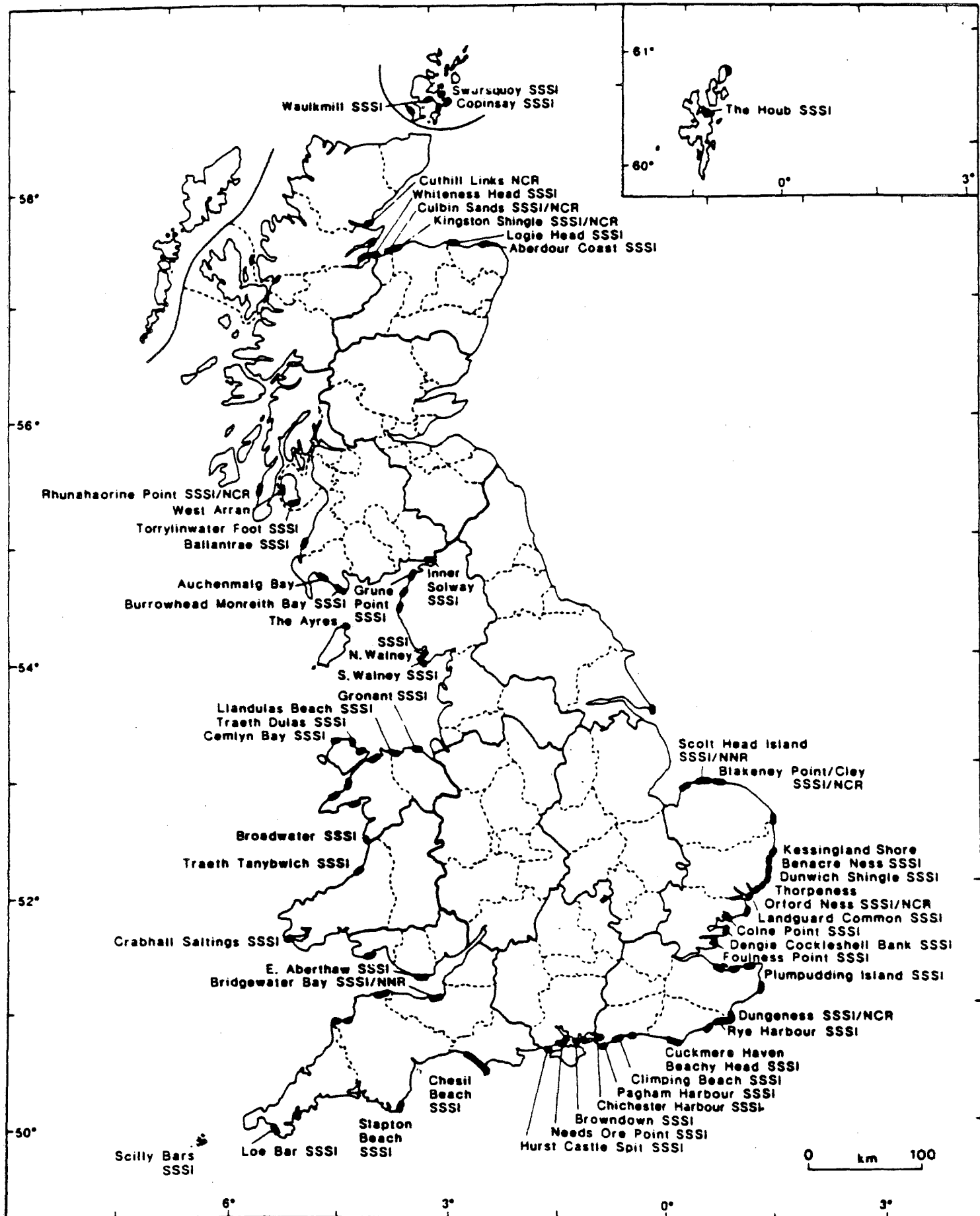


Figure 1. Distribution of the major areas of British shingle.

Nature Conservation Status

Recent reviews (Doody, 1989 and Randall, 1989) identified 7 shingle sites of national importance out of a total of 200 sites, including shingle, considered to be worthy of designation as Sites of Special Scientific Interest, or already notified. (Table 1).

TABLE I: Vegetated shingle structures in Great Britain within Sites of
Special Scientific Interest

Sites	Approximate area of SSSI (ha)
A: Sites of national importance	
1. Dungeness, Kent	2714
2. Orfordness-Havergate, Suffolk	1602
3. Blakeney Point, Norfolk	581
4. Chesil Beach, Dorset	1281
5. Culbin Shingle Bar, Moray/Nairn	12295*
6. Rhunahaorine Point, Argyll and Bute	327
7. Kingston Shingle, Moray	500
B: Other sites of significance	
1. Wall Common, Somerset	2460*
2. Slapton Ley, Devon	219
3. Browndown, Hampshire	64*
4. Pagham Harbour, West Sussex	384*
5. Rye Harbour, East Sussex	721
6. Colne Point, Essex	3806*
7. Languard Common, Suffolk	31
8. Scolt Head, Norfolk	738*
9. Walney and Foulney Islands, Cumbria	1909*
10. Cemlyn Bay, Gwynedd	45
11. Traeth Tanybwylch, Dyfed	36
12. East Aberthaw Coast, South Glamorgan	68
13. Whiteness Head, Inverness/Nairn	409
14. Copinsay, Orkney	152
15. Ballantrae Shingle Beach, Kyle and Carrick	34

*Sites where the important shingle areas represent less than 10% of the total site area.

Undoubtedly the most important single shingle structure is Dungeness. This shingle foreland has suffered extensive damage from a variety of activities including gravel extraction, military use, building of power stations and water abstraction. Despite this it retains extensive surface shingle showing the full range in the stages of development of vegetation.

Of the other sites, Orfordness is the only one protected in part as a National Nature Reserve. The majority of the rest of the sites are designated as Sites of Special Scientific Interest and protected by the legislation of the Wildlife and Countryside Act 1981. Despite this, threats have arisen and continue to arise and it is hoped that this work will form a more sound basis for their conservation.

The site descriptions are arranged in 7 geographical areas:-

Area 1	South East England
Area 2	South England
Area 3	South West England
Area 4	Wales
Area 5	North West England
Area 6	Scotland
Area 7	North East England

In each one there is a general description with further detail of typical or important sites.

Geographic Descriptions

AREA 1 - SOUTH EAST

General Description

The first geographical area contains the counties of Norfolk, Suffolk, Essex, Kent and East Sussex. Within this area the majority of the more important British shingle sites occur, representing some 65% of the total resource in Great Britain. There is one major concentration in Norfolk and Suffolk and another on the south coast which includes Dungess.

East Anglia

Norfolk and Suffolk contains two major shingle structures (Blakeney Point and Orfordness) which are composed largely of larger size pebbles. Whilst both sites support important examples of pioneer shingle communities, much of Blakeney Point is relatively young and more stable vegetation is relatively limited. By contrast the extensive Orfordness shingle has developed stable lichen-rich vegetation of considerable nature conservation significance. For detailed description see Fuller and Randall (1988) and below.

Typical Site

Blakeney Point, Norfolk

SSSI, NT

TG 015458

Blakeney includes a shingle spit of great physiographic interest (Fig. 2). The point has been the scene of extensive scientific research and educational work over many decades. The results of these have provided important observations on the formation and vegetation of coastal shingle. There is a massive storm ridge of shingle at Cley with salt-marsh behind. The windward face of the ridge is unvegetated but the lee has approximately 30% covering of Silene maritima with Rumex crispus var littoreus, Glaucium flavum, Festuca rubra, Festuca ovina, Artemisia maritima and Sonchus sp. In some places there are only cushions of Silene maritima but where the shingle is admixed with sand Honkenya peploides is common. There is a small area of Lathyrus japonicus that

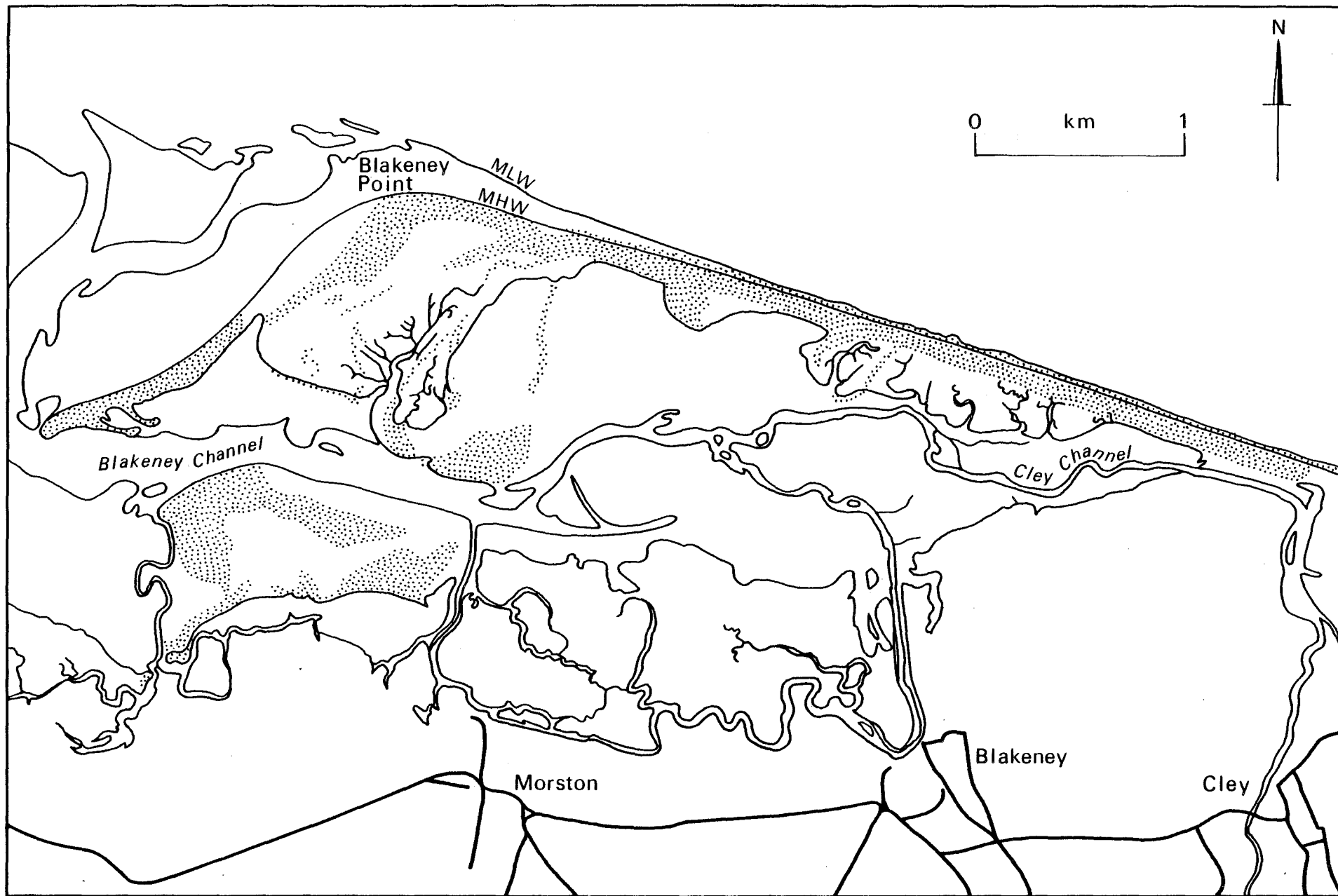


Fig. 2 Blakeney Point

has survived here since initial importation in the 1930s. The shingle bank slopes 8'-10' down to the marsh behind with a shingle/salt-marsh fringe of Suaeda vera (fruticosa) below Elymus pycnanthus. Much of the shingle is very fine 6mm or less) at the base of the ridge, grading to 25mm at crest with individual pebbles to 100mm.

To the west of Cley areas of the shingle have been disturbed by coastal defence works but occasional undisturbed patches have developed a Festuca ovina turf with Desmazeria marina, Lotus corniculatus, Plantago maritima, Taraxacum sp and Senecio jacobaea.

A low shingle recurve at Trinity House is covered with Festuca rubra and Armeria maritima above a broad belt of Suaeda vera, with Halimione portulacoides on shingle over mud at the marsh interface. In this area there are also stands of Limonium binervosum and some Frankenia laevis.

Around the derelict house several species including Stellaria media, Bellis perennis, Anagallis arvensis and several dune species are growing in the sand that overlies fine shingle.

Within the dune systems of Blakeney Point there are several low areas of shingle or shingle/sand mixtures. Where these are flooded at high spring tides a line of Frankenia laevis marks the location of maximum flooding. Sandy shingle is turfed with Agrostis tenuis and Corynephorus canescens with Silene maritima, Polytrichum juniperum, Galium verum, Senecio jacobaea and Hypochoeris radicata. Much of this shingle has been stable for long periods and has developed a rich lichen cover. This area has been studied by many contributors to the Trans. Norf. & Norwich Nat. Soc..

Elsewhere in Norfolk, shingle vegetation occurs in increasing quantities westward from Salthouse. Over much of the area sand occupying the interstitial spaces gives greater moisture-holding capacities and therefore sand-dune species are common; including Ammophila arenaria, Carex arenaria, Honkenya peploides and Sedum acre. Behind the Salthouse/Cley bank a few salt marsh/shingle species occur where shingle invades the back of the marsh. Particularly significant in this area is Suaeda vera (fruticosa). On the

ridges where the shingle has little sand admixture Rumex crispus var littoreus, Silene maritima and Glaucium flavum are common. Mertensia maritima was recorded here early in the century but was disturbed and partly buried by severe winter gales in 1911 and never recovered its vigour. It became extinct in the 1930s. A similar bank of shingle in the west of the county extends from Snettisham to Wolferton with a typical shingle foreshore flora.

The Suffolk beaches are mainly of shingle or shingle and sand. The sediment is derived from the erosion of cliffs at Covehithe, Easton Bavents, Dunwich and Bawdsey as well as from the seabed. In the north about one mile from Covehithe is Benacre Ness an interesting old sand and shingle beach with adjacent heathland and Broad. During the Second World War a large quantity of shingle was removed from this site, creating pits which sometimes flood. The most interesting plant here is the nationally rare Corynephorus canescens more typical of acid dune systems in the area. Crambe maritima is also present though much reduced due to human interference and erosion.

From Dunwich Gap to Walberswick the beach is mainly shingle with a rather unstable main ridge. This is constantly being eroded and needing repair after high-tides. The shingle beach was formerly quite wide over much of its length and was composed of a number of ridges representing former beaches. The majority of interesting plants which were known there previously have in recent times been destroyed by erosion, human interference or particularly by bulldozers piling up the shingle. This area is now very popular with holidaymakers.

Shingle recurs north of Thorpeness as far as Sizewell but much of this is mixed with sand and acts effectively as a sand beach. South of Thorpeness to Aldeburgh the shingle/sand mix has a higher proportion of shingle but heavily overrun by visitors. Lathyrus japonicus is present along this fringing beach but its most interesting species is the large population of Euphorbia paralias.

Typical Site

Orfordness-Havergate, Suffolk

SSSI, NNR(Part)

TM 400472

Orfordness, together with Shingle Street, is one of the three most important shingle landforms in the British Isles and is the only one which combines a shingle spit with a cusped foreland (Fig. 3a, b, c, d). This large feature comprises a complex sequence of shingle ridges deposited over many centuries. The distal end of the spit is still subject to rapid changes and is dynamically related to events at Shingle Street on the mainland shore. The site contains the second largest and the best preserved area of vegetated shingle in Britain. Lathyrus japonicus and Crambe maritima are abundant on the mobile pure shingle. The more stable acid grass heath supports huge areas of Silene maritima, Sedum anglicum and other heath species. A wide range of rare and local species are present including Vicia lutea and the dwarf clovers: Trifolium suffocatum, Trifolium glomeratum, Trifolium striatum, Trifolium scabrum and Medicago minima. Lichen communities are also well-developed with extensive areas of Cladonia heath. A unique feature of this site is the abundance of the normally epiphytic lichens Parmelia caperata and Evernia prunestri growing as ground cover.

On the leeward side of Orfordness at Shingle Street, and on Havergate Island, there are areas of shingle/salt marsh transition with Armeria maritima, Beta vulgaris spp maritima, Artemisia maritima, Halimione portulacoides and rarely Frankenia laevis. Shingle Street also has an area of sandy shingle where Festuca rubra turf is dominant, with Honkenya peploides and Crithmum maritimum. Disturbed areas of shingle are frequently colonised by Arrhenatherum elatius. Much of the northern part of Orfordness has been disturbed by military activity and Coastal Defence works.

FIG. 3a

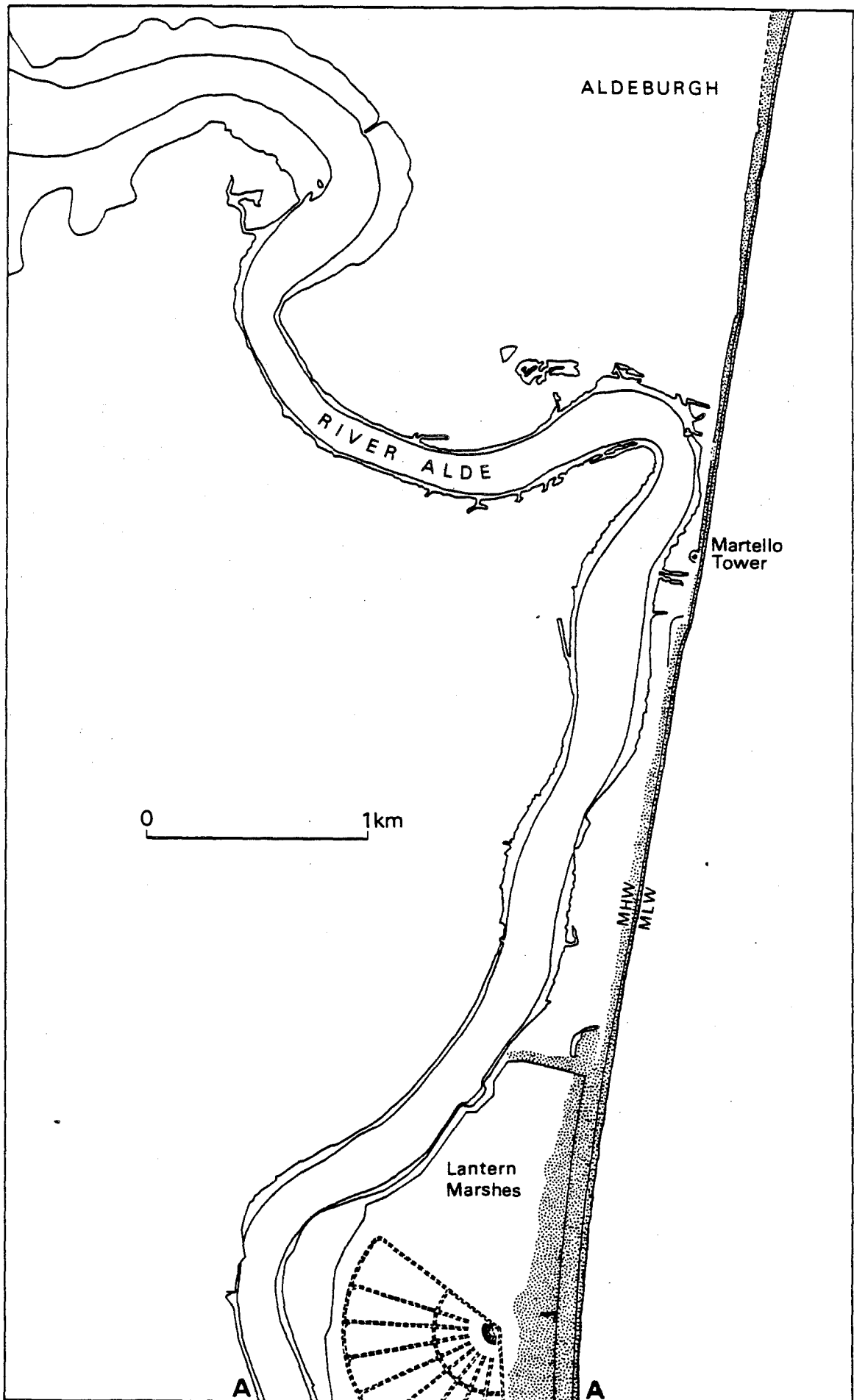


FIG. 3b

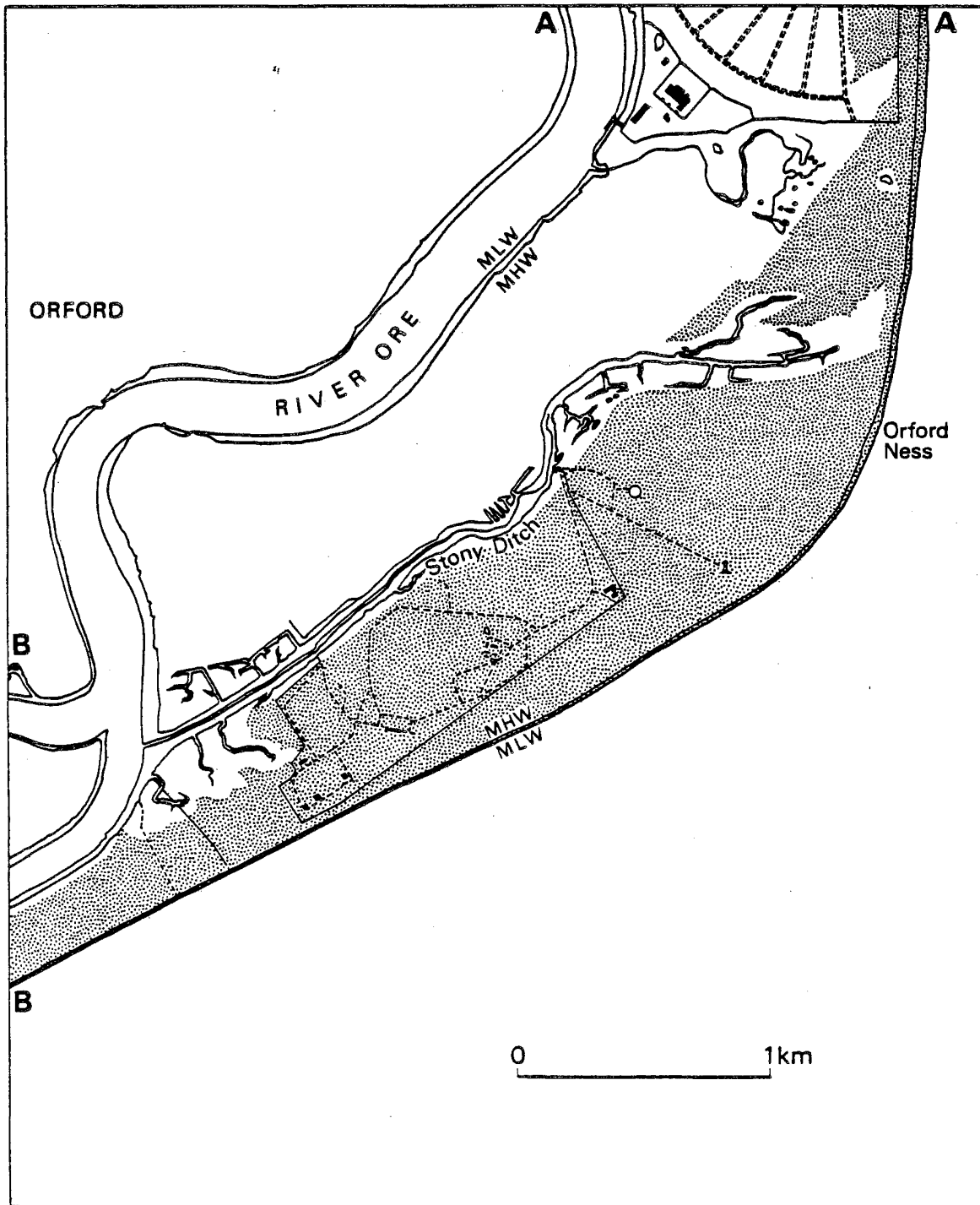


FIG. 3c

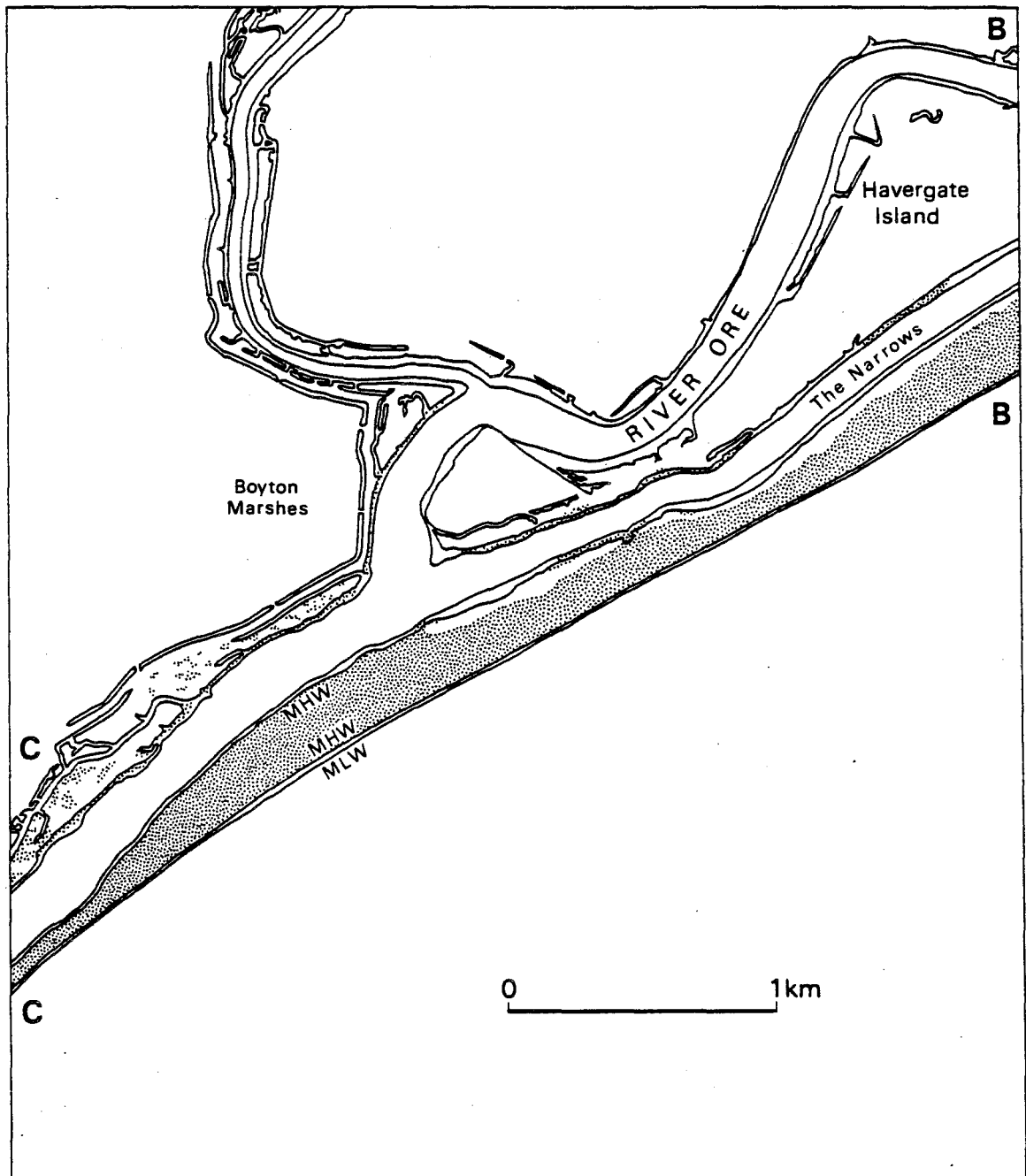
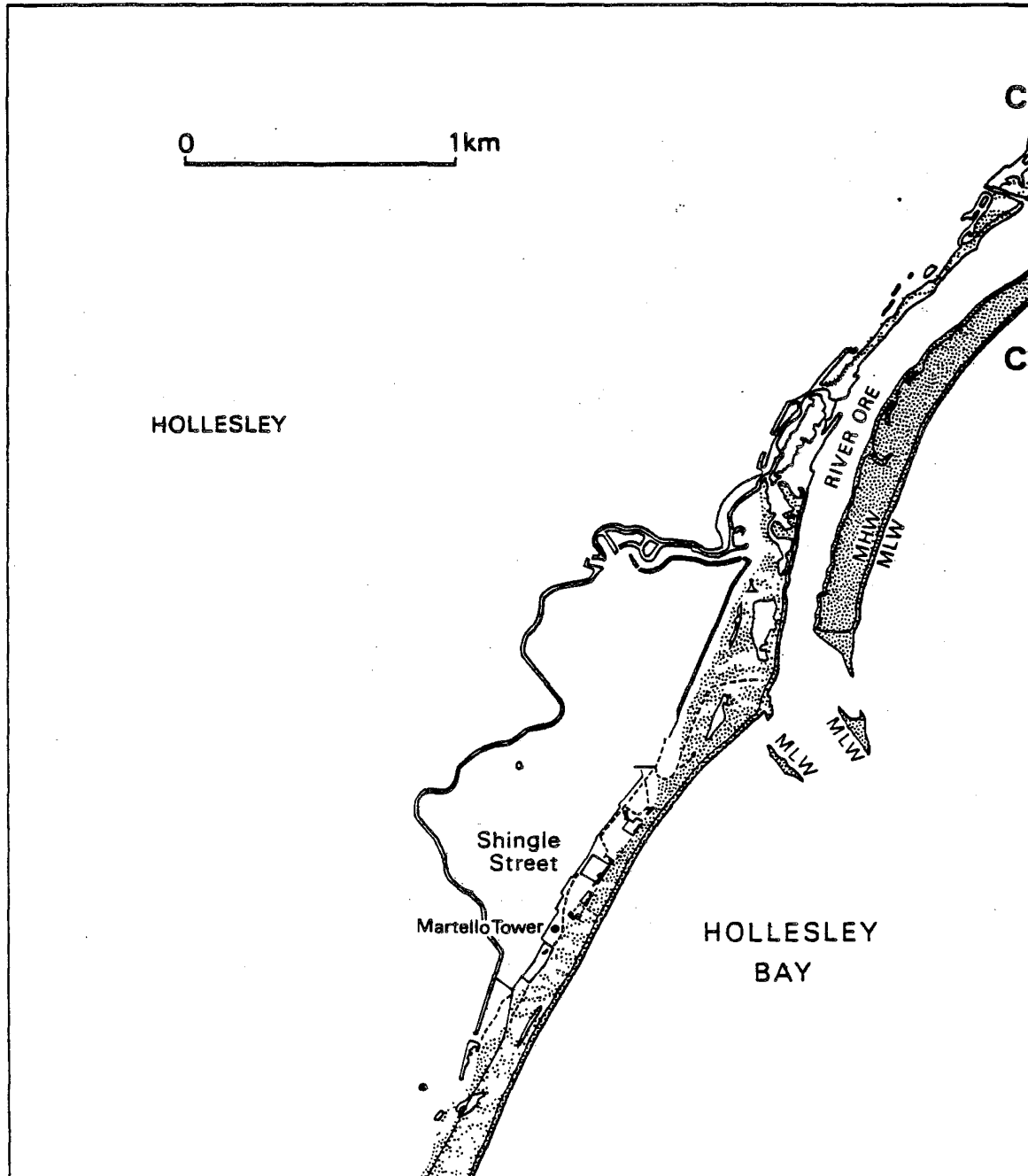


FIG. 3d



South of Shingle Street there is an extensive, mainly unfrequented shingle beach with some brackish pools. Lathyrus japonicus is abundant with Glaucium flavum and Vicia lutea. This beach extends down to the mouth of the River Deben where it is backed first by cliffs near Bawdsey Manor and then saltmarsh in the Deben estuary. The shingle recurs extensively at the mouth of the River Orwell as Landguard Common.

In Essex, Naze Point north of Walton-on-Naze is an area of mixed sandy shingle and saltings which is primarily important as a landfall for migrant birds. However the shingle areas provide nesting sites for the little tern, ringed plover and oystercatcher and has a sparse flora that includes Carduus tenuiflorus, Silaum silaus, Trifolium ornithopodioides, Trifolium fragiferum and Euphorbia paralias. This is the most extensive area of flint shingle in Essex. Where the pebbles are smaller with a lime-sand matrix Ammophila arenaria and Leymus arenarius grow with Calystegia soldanella, Crithmum maritimum, Eryngium maritimum, Lathyrus japonicus and Suaeda vera - a typical southern sandy-shingle flora (Crabknowe Spit).

Colne Point comprises two shingle spits enclosing 400 acres of saltings. The sandy shingle supports Eryngium maritimum, Calystegia soldanella, Euphorbia paralias and Glaucium flavum as well as many common shingle species. The area is important for its invertebrates and also has a high mammal population. It is the best developed spit on the Essex coast and shows parallel ridges at various stages of stabilisation.

Within the Dengie coast, which is primarily salt-marsh, is Bradwell Cackle Spit, 30 acres of sandy shingle enriched with cockle shells. It supports a small colony of little terns and ringed plover. The flora includes Suaeda vera, Glaucium flavum, Calystegia soldanella, Anchusa arvensis, Honkenya peploides, Salsola kali and Beta vulgaris. Lower shingle with silt shows transition to salt marsh with Frankenia laevis, Elymus farctus and Elymus pycnanthus.

At the north-eastern extremity of the Thames estuary is Shoebury Common, a vegetated enclosed beach with many old records of shingle beach flora and a 20ha cockle shell beach and spit. This is the most extensive shell-beach

accumulation in Britain, with classic sedimentation sequences. There is a very large colony of little and common terns and many waders use the area as a high-tide rest. The older shell banks support a lime-shingle flora including extensive strands of Glaucium flavum.

TABLE 2a

Shingle Structures in East Anglia

<u>Location</u>	<u>Shingle Extent</u>	<u>Type</u>	<u>Matrix</u>	<u>Significant Species</u>
Thornham West (Islands)	90h	barrier	none-sand	<u>Trifolium suffocatum</u> , <u>T. subterraneum</u>
Scolt Head (Island)	50h	barrier	none, sand silt	<u>Suaeda vera</u>
Cley-Blakeney Point	160h	Spit	none-sand	<u>Limonium binervosum</u>
Kessingland-Benacre	30h	Ness	sand	<u>Corynephorus canescens</u>
Dunwich-Walberswick	25h	multiple ridge	none	disturbed
Orford Ness	1200h	Ness	none	<u>Lathyrus japonicus</u>
Shingle Street	35h	multiple ridge	none, sand silt	<u>Lathyrus japonicus</u>
Landguard Common	31h	spit	sand	<u>Crambe maritima</u>
Colne Point	50h	spits	sand	<u>Eryngium maritimum</u>
Bradwell	12h	spit	cockle shell/sand/silt	<u>Frankenia laevis</u>
Shoebury Common/Foulness	40h	Ness & spit	cockle shell/sand	<u>Glaucium flavum</u>

South East - Kent and East Sussex

The other main split with this South Eastern zone centres around the major shingle system which runs from Rye Harbour (East Sussex) to Dungeness. This area of shingle is characterised by major accumulations, the most important being the Dungeness foreland. This is described in a number of places (see especially Ferry and Waters, 1985) as the most significant shingle structure in Great Britain and is important on a world scale (Ferry et al 1989).

The sites have received major adverse impacts from gravel extraction, building of roads, power stations and military activity, but nevertheless still support extensive and important vegetation.

One of the features of the sites is the presence of water bodies. These are largely natural in the case of the "Open pits" on Dungeness, but man-made at Rye Harbour and Dungeness where gravel extraction has created large areas of open water. In the case of the former, these have developed an internal woodland flora and fauna. Whilst the gravel pits of the latter support birds typically associated with that habitat in South East England.

Typical Site

Rye Harbour, East Sussex

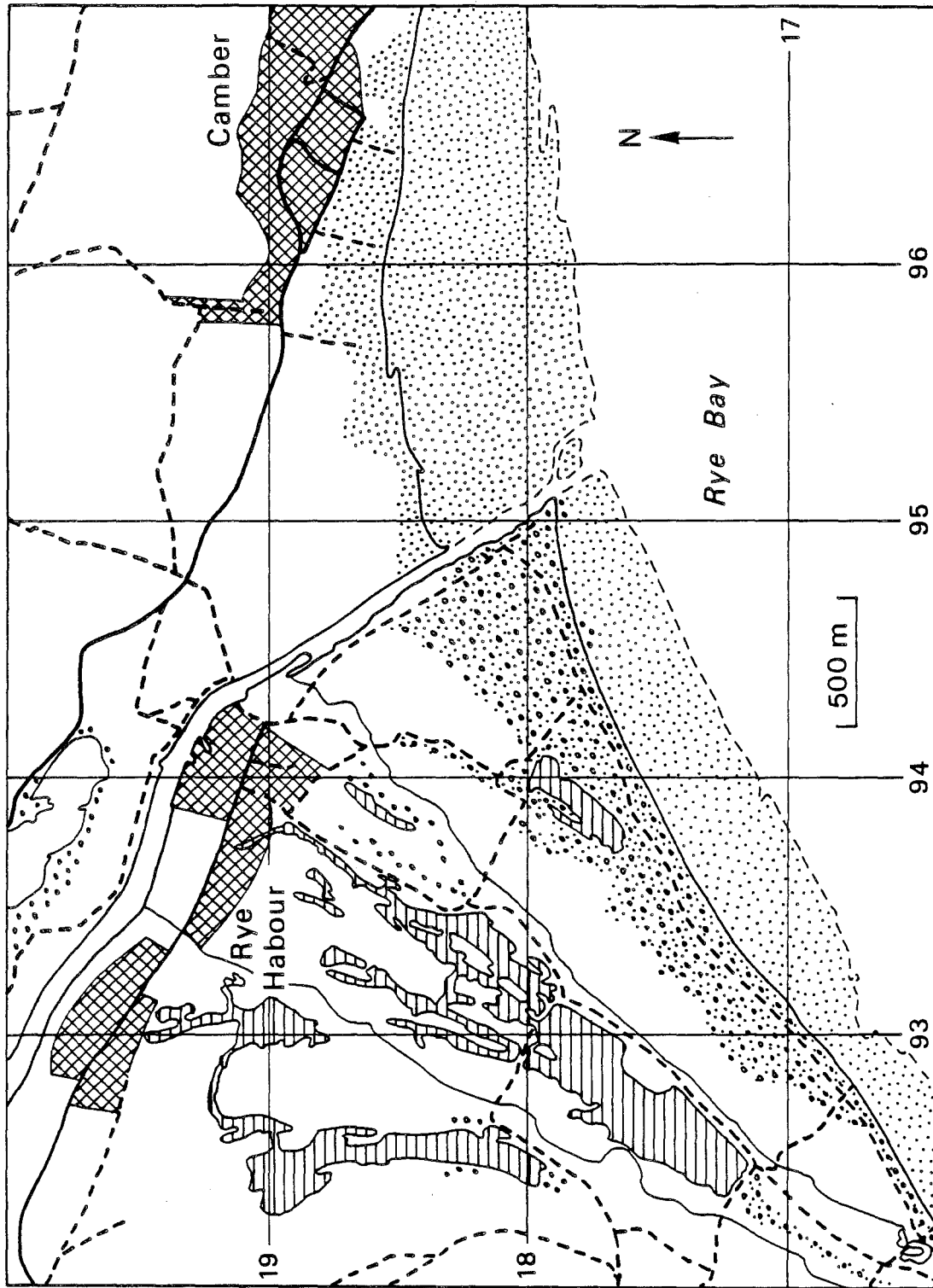
SSSI L.N.R.

TQ 935180

The large area to the east of the River Rother is the only extensive tract of shingle in East Sussex and is second only in extent to Dungeness in Southern Britain (Fig. 4). It is the locality of Lactuca saligna, scheduled for special protection within the Wildlife and Countryside Act, 1981.

The shingle beach has been accreting over many centuries in a southerly direction, creating a fan-shaped belt of sand and shingle. The belt is narrow in the west of the site and broadens rapidly to the east and north. The shingle ridges over the complex represent old shorelines, dating back to circa 12th century near Camber Castle. The range of plant communities that have developed reflect the age of the shingle ridges and the degree of maritime

Fig. 4 Rye Harbour



influence. Shingle has been extracted over parts of the area giving pools and lakes bordered by fen vegetation.

The main coastal ridge and the shingle plain behind are unstable and exposed and only sparsely vegetated. Nevertheless this site has a rich flora including Cakile maritima, Glaucium flavum, Rumex crispus, Armeria maritima, and extensive strands of Lathyrus japonicus. Besides Lactuca saligna this area also supports other rare species including Vulpia ambigua, Hordeum marinum, Bupleurum tenuissimum and Crambe maritima. In low areas of shingle/saltmarsh transition there are Puccinella fasciculata and Puccinellia rupestris.

Further inland the shingle is more stable and less windswept resulting in a grass heath dominated by Festuca rubra, Festuca ovina and Hordeum secalinum. Especially where there is considerable sand matrix this sward contains many herbs including Trifolium suffocatum, Trifolium ornithopodioides, Teesdalia nudicaulis, Moenchia erecta, Cirsium acaule, Festuca heterophylla and Cerastium tomentosum. Disturbed areas have a scrub cover of Ulex europaeus and Sambucus nigra with Rubus fruticosus on old rabbit warrens. Stable undisturbed ridges are rich in lichens including Cladonia furcata, Cladonia foliacea, Cladonia sylvatica, Cetraria aculeata and Xanthoria parietina.

Shingle islands in some of the larger lakes carry a number of unusual plants particularly Epipactis palustris, Dactylorhiza praetermissa and Sedum anglicum.

Elsewhere in the south-east there is an interesting but heavily disturbed area of shingle below the Crumbles. Though once important from a vegetation point of view gravel extraction and gross disturbance of the surface shingle has all but destroyed the conservation interest. Across the Thames estuary from Foulness is the extensive NNR of the Swale where there are similar shell accumulations at Shellness, Isle of Sheppey, and Castle Coote west of Seasalter. The shells here are of many species especially Cardium edule, Mytilis edulis, Ostrea edulis, Mya arenaria and Macoma baltica. These break down to give a lime-rich shingle of a sandy nature on which Crambe maritima, Glaucium flavum, Ammophila arenaria and Cakile maritima are common. Eryngium maritimum and Euphorbia paralias are also present and this is the only Thames site for Polygonum oxyspermum. The Atriplex spp. for these sites have

been described by Badmin (1977). An unusual naturalised alien pea,
Tetragonnoobus maritimus also occurs here.

Further east, Plumpudding Island, Kent, includes a short stretch of shingle backed by the northern sea-wall has a rich fringing beach flora including a large colony of Lathyrus japonicus along with Glaucium flavum, Beta vulgaris subsp. maritima and, where the silt content in the matrix is high, Aster tripolium.

At Cuckmere Haven in East Sussex shingle banks have developed on either side of the mouth of the Cuckmere River. On the east side the shingle is most extensive but both sides support a representative flora including good populations of Rumex crispus, Beta maritima, Glaucium flavum and Tripleurospermum maritimum. There is a good spread of Calystegia soldanella on the west bank of the river.

Table 2b

Shingle Structure in Kent and East Sussex

<u>Location</u>	<u>Shingle Extent</u>	<u>Type</u>	<u>Matrix</u>	<u>Significant Species</u>
Shellness	20h	spit	cockle shell/sand	<u>Polygonum oxyspermum</u>
Plumpudding Island	10h	ridge	none-silt	<u>Aster tripolium</u>
Walmer	15h	multiple ridge	none	<u>Lathyrus japonicus</u>
Dungeness	2714h	cusped foreland	none	<u>Cytisus scoparius</u>
Rye Harbour	720h	aposition banks	none- sand	<u>Lactuca saligna</u>
Cuckmere Haven	10h	multiple	sand	<u>Calystegia soldanella</u>

AREA 2 SOUTH

The Chesil beach forms the most significant feature along this stretch of coast. However, it is in the geomorphological context that the site is best known. The Lagoon is also important and provides interesting shingle/saltmarsh transitions with Suaeda vera. There are patches of vegetation which include extensive Lathyrus japonicus, Crambe maritima and Euphorbia portlandica at the western end.

Whilst Chesil is the most readily recognised site, the area also includes several other important sites of which Browndown is probably the most significant. Like Dungeness, the vegetation, though disturbed, shows transitions into acid grass heath which is indicative of considerable age and stability. By contrast the shingle at Pagham Harbour is more mobile and occurs in combination with other coastal habitats.

Elsewhere in the south there are several significant vegetated shingle sites. In the east Climping west beach is a classic short stretch of shingle foreshore backed by a line of dunes and a golf course. Parts of this area are sparsely vegetated but the western end has retained a good flora with abundant populations of Crambe maritima and Glaucium flavum. Both species show a linear distribution suggesting that their location is related to previous drift lines. Other species present are Sedum acre, Rumex crispus, Silene maritima and Honkenya peploides where additions of sand are greater.

There is a sandy shingle spit in the grounds of Sandy Point Hospital, Hayling Island which contains populations of Polygonum oxyspermum, Erodium cicutarium ssp bipinnatum (a local mainly west coast plant), Ulex gallii, Genista tinctoria, Filago minima, Myosotis ramosissima, Arphanes arvensis, Ornithopus perpusillus, Vicia lathyroides, Trifolium micranthum, Trifolium scabrum, Trifolium suffocatum, Trifolium ornithopodioides and Euphorbia paralias. Cuscuta epithymum commonly parasites the low-growing Ulex. Eastney beach at the eastern end of Portsea Island is also well-vegetated. In the west of the country there are shingle spits at the estuaries of each of the main rivers, continuing to Hengistbury Head spit at Mudeford/Christchurch, in Dorset.

Chichester Harbour contains quite extensive shingle islands and a shingle spit enclosing the Harbour. However in comparison to Pagham or Browndown, much of the shingle is rather unstable and little vegetation has become established. Terns and ringed plover breed extensively on the Chichester shingle. Along the West Wittering coast leading up to East Head spit there is an extremely rich fringing beach flora including Rumex crispus var littoreus, Silene maritima, Honkenya peploides, Crambe maritima, Glaucium flavum and Sedum acre.

Hurst Spit is a well-developed shingle spit with terminal recurved shingle ridges. It contains important transitions from salt-marsh to shingle, marked by an abundance of Inula crithmoides, Armeria maritima and Halimione portulacoides. The lows between the shingle ridges contain salt-marsh species and where permanently wet Eleogiton fluitans. Some of the more stable ridges have grass-heath with Festuca rubra and Elymus farctus, grading to Ulex, Crataegus and Quercus scrub. The more open areas have spreads of Silene maritima, Cochlearia danica and the rare Geranium purpureum. Smaller populations of Glaucium flavum, Crambe maritima and Atriplex spp are also found.

The shingle spits at Newton Harbour on the Isle of Wight are only small (about 8ha) but carry a good representative southern shingle/marsh transition flora including abundant populations of Frankenia laevis, and Inula crithmoides.

In the Beaulleigh Estuary, Hampshire, there are spits at Calshott and Needs Ore Point and a fringing shingle beach along Stanswood Bay. The fringing beach is sparsely vegetated but the spits have shingle with a clay matrix resulting in a peripheral salt-marsh flora above which there are extensive areas of Inula crithmoides grading into Festuca/Elymus grasslands.

Typical Sites

Pagham Harbour, West Sussex. LNR/ SZ 870967

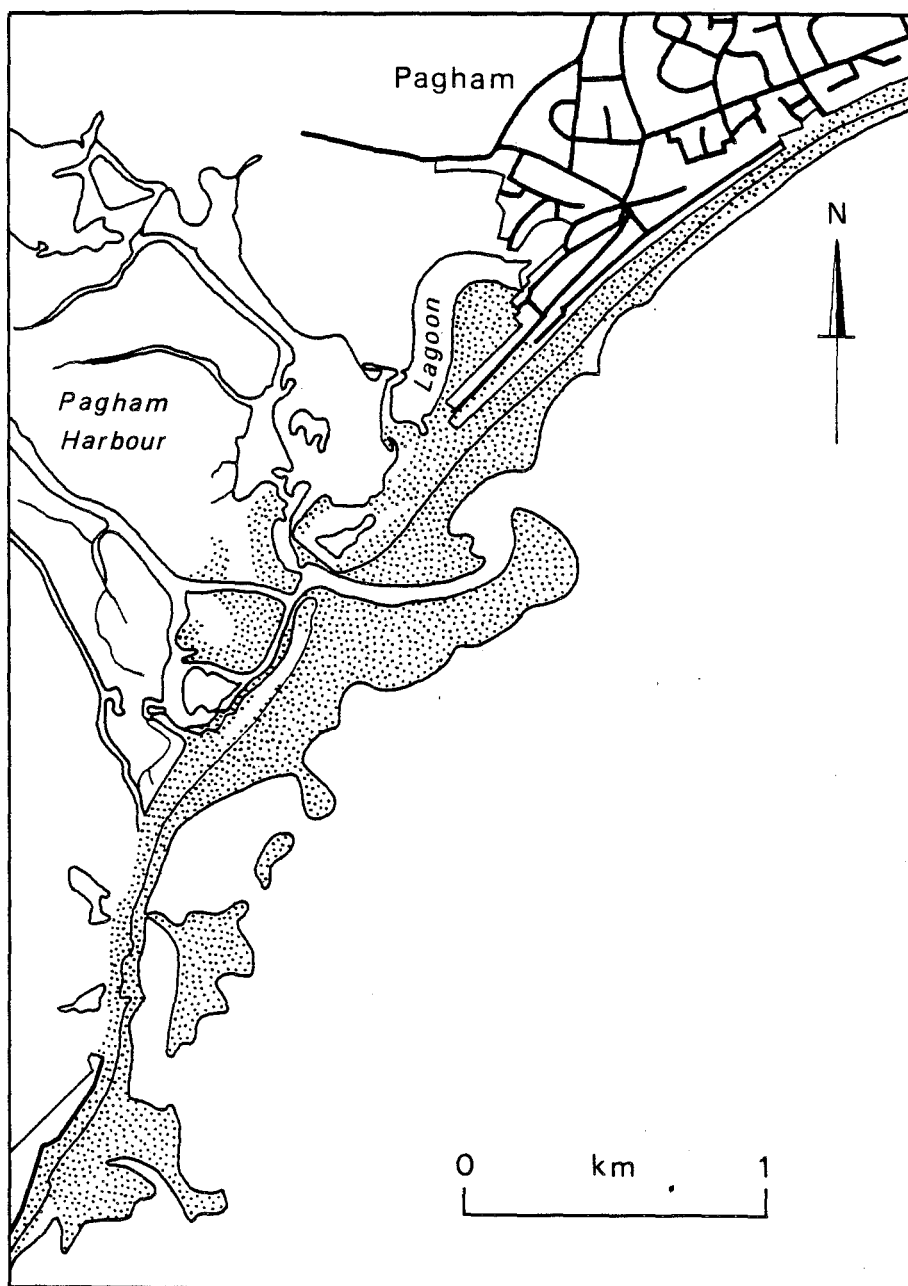
SSSI

One of the few areas remaining undeveloped on the West Sussex coast. The major areas of shingle are the Pagham shingle spit to the north and the Church Norton shingle spit to the south of the harbour entrance (Fig. 5).

The shingle banks. On their seaward side the continuous movement of the shingle as far up as that affected by the winter gales, prevents any plant growth. The upper limit of this zone is marked in Summer by a prolific growth of Atriplex glabriuscula (Babington's Orache) often accompanied by A. littoralis (Shore Orache). Further from the sea an open community (i.e. one in which there are bare areas between the plants) is found, consisting of isolated or small groups of plants belonging to the following species:

<i>Solanum dulcamara</i> var. <i>marinum</i> - Bittersweet	a
<i>Rumex crispus</i> var. <i>littoreus</i> - Curled Dock	c
<i>Geranium robertianum</i> var. <i>marinum</i> - Herb Robert	c
<i>Atriplex glabriuscula</i> - Babington's Orache	c
<i>Arrhenatherum elatius</i> - Oat Grass	f, la
<i>Cirsium vulgare</i> - Spear Thistle	f

Fig. 5 Pagham Harbour



Pagham ~ N of Seusey

Silene maritima - Sea Champion	f
Crambe maritima - Sea Kale	lf
Glaucium flavum - Sea Poppy	lf
Echium vulgare - Viper's Bugloss	lf
Heracleum sphondylium - Cow Parsnip	o
Beta maritima - Sea Beet	o
Senecio viscosus - Stinking Groundsel	o
Sonchus asper - Spint Sowthistle	o
Senecio jacobaea - Ragwort	o
Daucus carota - Wild Carrot	o
Vicia hirsuta - Hairy Tare	o
Stellaria pallida - Lesser Chickweed	o
Agrostis stolonifera - Fiorin	o
Ranunculus repens - Creeping Buttercup	o

a=abundant, c=common, f=frequent, o=occasional, l=locally.

Solitary plants of Lathyrus japonicus (Sea Pea) and Euphorbia paralias (Sea Spurge) occur here. On the Pagham spit the Red Valerian (Centranthus ruber) is frequent, probably having spread there from the beach bungalow gardens.

To landward, patches of closed communities are formed by the accumulation of decaying vegetation producing a soil rich in organic matter around small groups of the above mentioned plants, so that areas of turf or groups of bushes, mainly gorse (Ulex europaeus) or bramble (Rubus fruticosus agg.) are found, the latter often surrounded by fine short turf. This latter type of vegetation is well developed on the landward side of the Little Lagoon especially in areas where the pebbles are small so that a gravelly soil results. A similar fine turf is developed at the side of the track to the harbour mouth and in the car park area though this appears to be due to gravelly soil introduced artificially to build the track. The fine turf community contains many attractive swarf plants such as Cerastium atrovirens (Dark-green Mouse-ear chickweed), Myosotis ramosissima (Early Forget-me-not), Erophila verna (Whitlow Grass), Veronica arvensis (Wall Speedwell), Cerastium glomeratum (Sticky Mouse-ear Chickweed), C. holosteoides (Common Mouse-ear Chickweed), Sedum acre (Stonecrop), Trifolium striatum (Soft Trefoil), T.

scabrum (Rough Trefoil), T. dubium (Lesser Yellow Trefoil) and T. subterraneum (Subterranean Trefoil). The predominant grass is Fesutca rubra (Creeping Fescue) and Aira praecox (Early Hair Grass) is common. The mosses Hypnum cupressiforme (Cypress-leaved Feather Moss) and to a lesser extent Ceratodon purpureus are common constituents and several fruticose or foliaceous lichens such as Cladonia rangiformis, C. chlorophaea and C. conista also occur. A similar type of vegetation occurs to the landward of the shingle beach in front of the Severals. Areas of coarse grass with Agropyron pungens (Sea Couch) occur in the vicinity of the Severals and on the northwest of the Little Lagoon. In places near the latter and also around its shores, saltmarsh vegetation with Salicornia spp. (Glassworts), Suaeda maritima (Sea Blight) and Halimione portulacoides (Sea Purslane) occurs. The Little Lagoon contains salt water derived by percolation from the sea through the shingle bank along its southeast margin and no flowering plants grow in it.

The shingle area between the Lagoon and the Pagham beach bungalows, although it has apparently been undisturbed for a long time, possibly around 120 years, has still only the open type of vegetation already described for shingle banks. Oat grass (Arrhenatherum elatius) is the dominant and often the only flowering plant present. The lagoon banks on the other hand are largely occupied by gorse thicket (Ulex europaeus) mixed with some hawthorn (Crataegus monogyna) and broom (Sarothamnus scoparius) and there is an occasional low-growing apple tree, probably the issue of a long-discarded apple core. On the ground under the bushes a mantle of ivy (Hedera helix) is often found.

Browndown, Hampshire
SSSI SZ 580990
MoD Property

Browndown (Fig. 6) is an extensive shingle system comprising a disturbed sequence of shingle ridges supporting acid heath communities behind a beach fringe. The oldest shingle supports acid, dwarf-shrub heath similar to Dungeness but dominated by Calluna vulgaris, and locally Erica cinerea or Ulex minor. Agrostis setacea is also abundant. This community is rich in lichens including species of Cladonia. In places Teucrium scorodonia and Rosa pimpinellifolia occur. This community is being invaded in some areas by Ulex europaeus, Rubus fruticosus and Pteridium aquilinum. Such heath is extremely fragile and parts have been disturbed by military activity. A heath community comparatively rich in lichens is probably not represented elsewhere in lowland Britain.

Acid, unimproved grass heath is also present. This is dominated by Agrostis setacea, Agrostis tenuis, Festuca tenuifolia and Festuca rubra. Silene nutans and Rumex acetosella are locally abundant. This area is also lichen rich, and is quite similar to Denge Beach, Dungeness. Pteridium is also invading parts of this community. Near to the beach this community becomes more open and is colonised locally by Arrhenatherum elatius, Festuca ovina, Armeria maritima, Silene maritima and prostrate Rosa pimpinellifolia.

Near the estuary of the River Alver there is a very sparse community of Anisantha sterilis, Bromus mollis and Elymus pycnanthus in which Carduus tenuiflorus and the rare Geranium purpureum ssp Forsteri are locally abundant.

Mixed scrub with Ulex europaeus, Prunus spinosa, Quercus ssp., Rubus ssp., Lonicera periclymenum, Sambucus nigra and Sarothamnus scoparius occurs in patches across the heath and supports the rare Dartford Warbler.

Small hollows over the beach, associated with military disturbance, have damper shingle colonised by Juncus effusus or salt-marsh species: Juncus maritimus, Juncus gerardii, Halimione portulacoides and Aster tripolium.

Fig. 6 Browndown

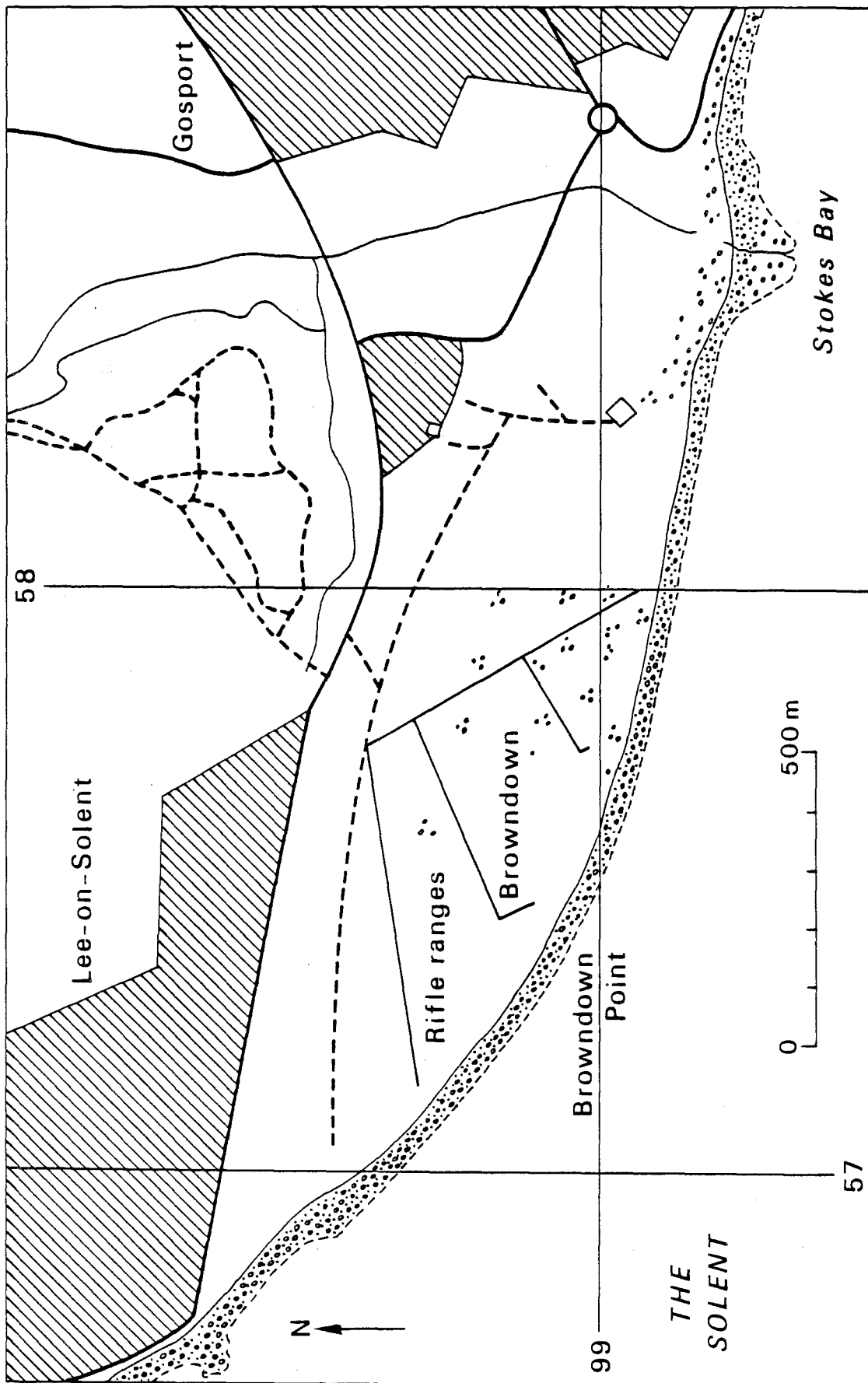


TABLE 3

Shingle Structures in Southern England

<u>Location</u>	<u>Extent/Type</u>	<u>Matrix</u>	<u>Sign Species</u>
Climping Beach	beach ridges	sand	<u>Crambe maritima</u>
Pagham Harbour (West Wittering)	spits	none/sand/silt	<u>Glaucium flavum</u>
Chichester Harbour	spit	none	-
Langstone Harbour	spit	sand	<u>Ornithopus</u> <u>perpusillus</u>
Browndown	cusped foreland	none/sand	<u>Calluna vulgaris</u> <u>Geranium purpureum</u>
Calshot Spit (Beaulieu Estuary)	spits	silt/clay	<u>Inula crithmoides</u>
Needs Ore Point	spits		
Hurst Castle	spit	silt/clay	<u>Inula crithmoides</u>
Hengistbury Head	spit	?	?
Chesil Beach	bar	none	<u>Lathyrus japonicus</u>

AREA 3 SOUTH WEST

There are no major shingle structures within this geographical area, although the beach in Bridgewater Bay forms a significant example of a sequence of large pebbled vegetated beaches with successional development from Geranium robertanum to Prunus spinosa.

Elsewhere the sites are scattered and represent examples of bars developed under high-energy coastal conditions. The most extreme of these occur in the Scilly Isles (see sites description). Loe Bar and Slapton are also important because of their associated lagoons.

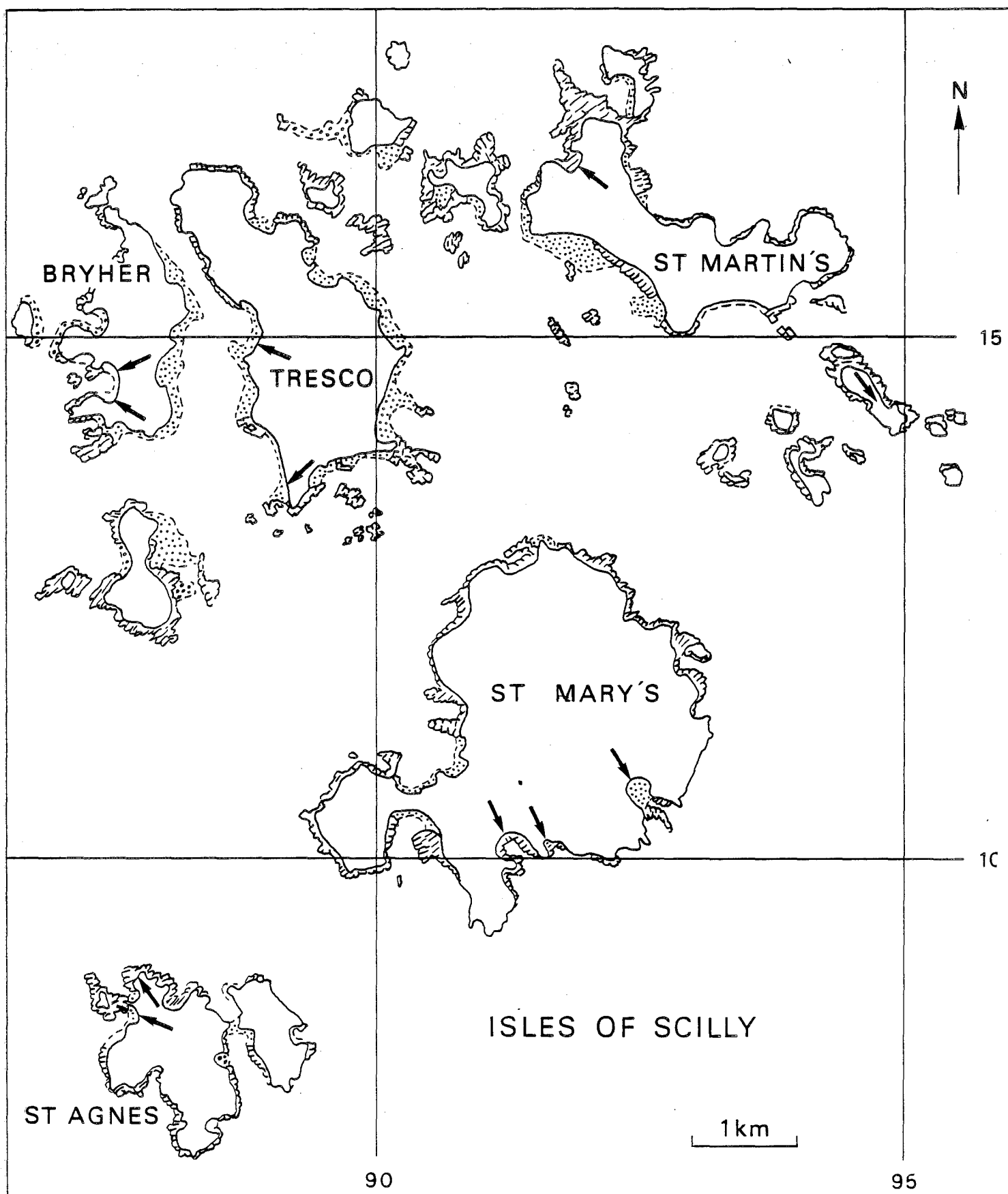
Typical Sites

Isles of Scilly, SV 9013 Grade I SSSI internationally important.

The distribution map (Fig. 7) usefully defines the major locations of shingle. In all vegetated shingle covers about 10ha but it is mostly bay-fringing storm beaches none more than 1ha in extent. On many of the shingle and boulder shores the most abundant species is Beta vulgaris ssp. maritima which grows in a very luxuriant and succulent form. Also abundant are Glaucium flavum, Solanum dulcamara and Tripleurospermum maritimum. Common species are Cochlearia danica, Sagina maritima, Spergularia rupicola, Crithmum maritimum, Cirsium vulgare, Carduus tenniflorus, Sonchus oleraceus, Armeria maritima, Atriplex ssp. Rumex crispus var littoreus and Festuca rubra. Locally the larger sites contain Cochlearia officinalis, Lavatera arborea, Rumex rupestris and Crambe maritima. At Wingletang and Porthellick Bays the shingle is under 6mm diameter and thus many sandy shore species are present such as Cakile maritima, Honkenya peploides, Salsola kali, Atriplex laciniata, Eryngium maritimum etc. Because of the large number of aliens in the Scilly flora, it is not surprising to find a varied and impermanent assortment locally on shingle beaches.

Davey (1910) recorded Lathyrus japonicus as extinct and it is not mentioned by Lousley but the record for 1972 (Margetts-Davis 1981) is an important westward extension of range for this declining species.

Fig. 7 Scilly Isles



SLAPTON LEY SX 827437 Grade I SSSI

This site (Fig. 8) is a mainly unvegetated, small pebble shingle beach, 20h in extent which encloses a large, eutrophic freshwater lagoon. On the seaward side there is a large tidal range of 2.5m. This area is heavily trampled by visitors but is important as the largest most south-westerly shingle unit in Britain. There are large populations of several south-western species including Polygonum oxyspermum, Raphanus maritimus, Rumex rupestris, Echium vulgare and Glaucium flavum. The more disturbed fringing shingle has well-established and increasing colonies of Lathyrus japonicus growing in association with Glaucium flavum, Beta maritima, Ononis repens, Crithmum maritimum, Calystegia soldanella, Festuca rubra and arenaria, Silene maritima, Atriplex glabriuscula, Daucus carota, Euphorbia paralias, Tripleurospermum maritimum and Elymus farctus. The SSSI is extensively used for courses run by the Slapton Ley Field Studies Council Centre and is probably one of the best documented shingle sites in Great Britain. The lichen flora of the site is outstanding including many characterisitic Lusitanian and Mediterranean species rare in north-west Europe.

The west coasts of Cornwall and Devon are very high-energy shores where shingle beaches of the fringing type are subject to considerable movement and have extremely sparse vegetation. Polygonum raii occurs near Hale in St. Ives Bay. Westward Ho, in Bideford Bay, is a classic example of unvegetated high-energy mobile shingle. Braunton Burrows has intertidal shingle flats with some vegetated foreshore. Polygonum maritimum was recorded here by Davey (1910) but is now limited to Lantic Bay, Cornwall.

Conversely, the north-facing shores of Devon and Somerset have more vegetated shingle, some of which extends far enough inland for some successional sequences to be recorded. The major sites are Linton shore, Porlock Bay and Bridgewater Bay.

Fig. 8 Slapton Ley

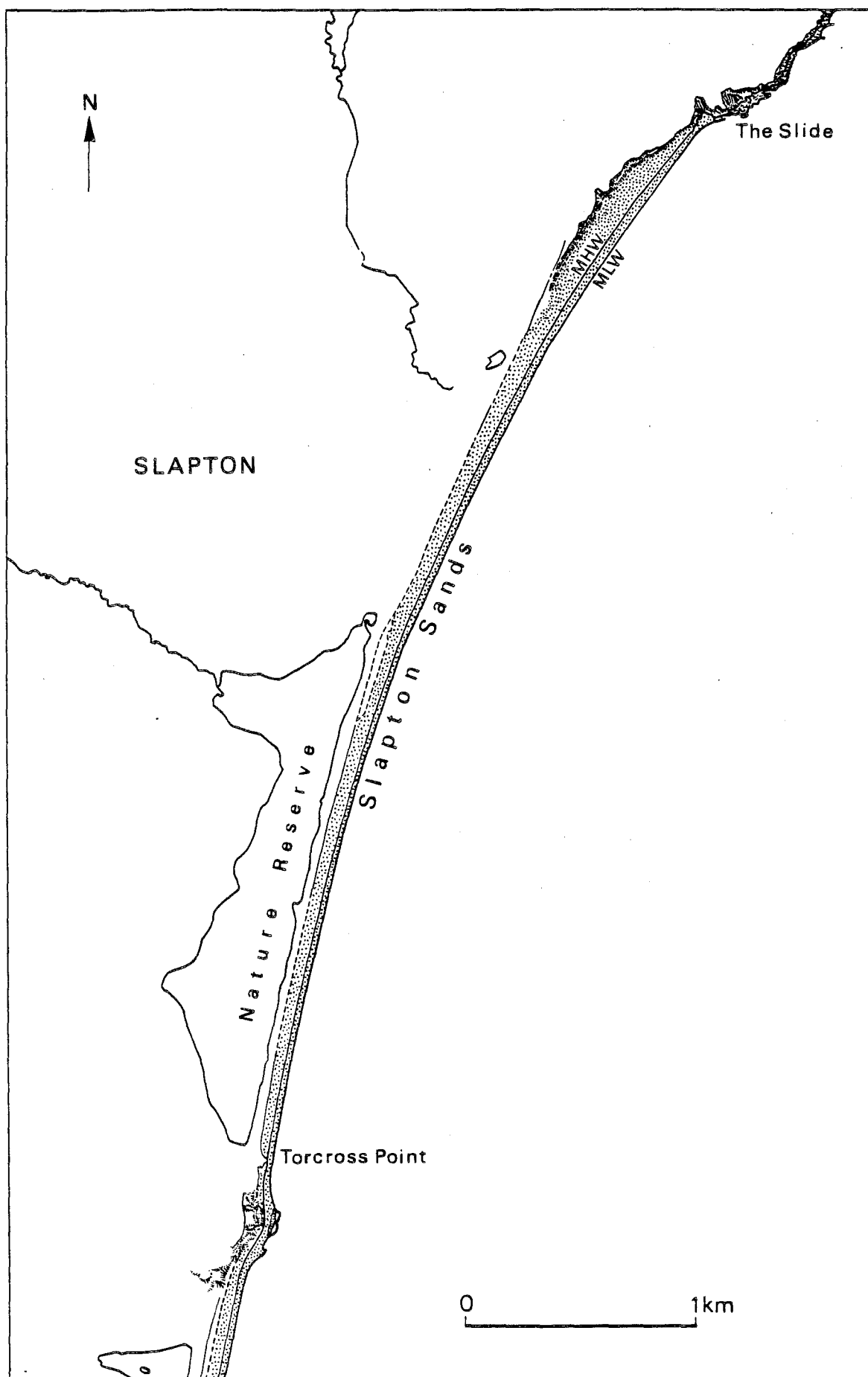


TABLE 4

SHINGLE STRUCTURES OF SOUTH-WEST ENGLAND

Slapton	bar	none	<u>Rumex rupestris</u>
Loe	bars	none/sand	<u>Rumex rupestris</u>
Scilly	bar		
Bridgwater	beach ridges	none	<u>Prunus spinosa</u>

AREA 4 WALES

The Glamorgan coast has several fringing shingle beaches with a vestigial flora, but only the area at the mouth of the River Thaw is of importance. There is a small area of vegetated shingle topping the beach at Porthkerry (ST102661-082662) and another between the beach and the dunes and saltmarsh at Merthyr-Mawr (SS860760). Here the vegetation on the shingle relates similarly to the adjacent habitats because of the influence of the relevant interstitial material. At East Aberffrw there is a small site, which consists of enclosing shingle ridges with sometimes large pebbles, which has important transitions to saltmarsh. The lagoon which lies behind the site is no longer natural. The saltmarshes exhibit important transitions with Limonium binervosum, rayless Aster and Parapholis. The shingle beach itself includes Geranium robertianum and Crithrum maritimum. There is an old shingle bank which lies below the cliff line. This has an interesting flora which includes Thymus praecox and Spiranthes spiralis. From Kenfig Dunes to Morgan Burrows (SS783816-SS774844) there is a long shingle beach, overlayed by sand in places, between the dunes and the foreshore. This is partly within a (Grade 2) SSSI and is interesting in that there is constant colonisation of the shingle by the plants of the fore-dunes: Elymus farctus, Ammophila arenaria, Cakile maritima etc. However the main interest in this site is the dune slack flora. Within the (Grade I) SSSI on the South Gower coast there are small traces of shingle in Oxwich Bay and a shingle bar across the Bishopston Pill and small Gower stream and Pwll-Du storm beach. The latter area has a varied but small flora including Crambe maritima. At Burry Inlet (SSSI) SS419993-560957 there are traces of shingle with local accumulations of Cardium edule shells. This has scattered vegetation.

Pembrokeshire is virtually bereft of vegetated shingle. The one or two sites where small pockets occur are heavily trampled by tourists in the summer months. Pickleridge at Dale, however, has some reasonable populations of Polygonum oxyspermum sub sp. raii among flat 7-20 cm cobble, with organic debris and sand in interstices. This is the only population extant in Dyfed. Elsewhere at Pickleridge there are good populations of Medicago arabica and Trifolium ornithopodioides. Near the saline lagoon there is a shingle/salt marsh transition with Armeria maritima, Beta maritima, Plantago maritima, Parapholis strigosa, Salicornia pusilla, Atriplex hastata and Tripleurospermum

maritimum. Rumex crispus and Glaucium flavum are found on the higher shingle. Much of the shingle of Cardigan Bay is highly mobile and non-vegetated but some estuarine sites deserve mention. In the Dyfi estuary, a vestigial shingle beach flora is found within the SSSI (SN6391). Although the angiosperms are the common species of shingle, some of the lichens of the backshore shingle are of limited western distribution. At Broadwater SSSI (SH582027) the shingle spit is only sparsely vegetated with Silene maritima and some rarer species including Glaucium flavum. Likewise in Tremadoc Bay, most west-facing shingle is mobile and extremely sparsely vegetated but the eastern beach at Criccieth with lower tourist pressure than the west and a southerly, lower-energy aspect, has considerable vegetation cover on 50mm-80mm diameter flat shingle discs with a sand matrix. The vegetation occurs mainly between the summer drift line and the storm drift line, with Salsola kali in the drift and Atriplex glabriuscula (a), Silene maritima (l.a.), Honkenya peploides (c), Rumex crispus var trigranulatus (c), Tripleurospermum maritimum (l.c.), Beta vulgaris maritima, Sonchus asper, Holcus lanatus, and Senecio vulgaris around the storm beach. Much of the shingle between the storm shelf and the onset of inland vegetation is without matrix and supports only the occasional Rumex crispus plant.

Traeth Tanybwllch is a sand and shingle spit running north from Allt Wen cliffs to the mouth of the River Ystwyth. The northern part of this is a shingle ridge, lying between the river and the sea, traversed by a rough track. The seaward side of the ridge is uncolonised with stones becoming larger towards the northern end. The crest of the ridge and the slope down to the track are initially colonised by Silene maritima and Geranium robertianum ssp. maritimum but this develops into a closed Festuca rubra sward with Koeleria cristata, Cerastium semidecandrum, Trifolium scabrum, Sedum acre and a large number of other ruderal and grassland species. Between the track and the Ystwyth the shingle has been stable for a long period and supports quantities of prostrate Prunus spinosa. On this and the shingle there is a characteristic lichen community including Acarospora atrata. Among the lichens Viola riviniana is common. The sandy shingle to the south has smaller stones and is dominated by Sedum anglicum and Ulex europaeus with patches of grass heath containing Festuca ovina, Agrostis tenuis, Aira caryophyllea and Jasione montana.

Further round the Lleyn peninsula there are extensive systems at Afon, Dwyfor, Porth Cerviad, Hell's Mouth. and Aberdaron, but all are high-energy beaches with scattered Atriplex spp. Tripleurospermum maritimum and Rumex crispus. Likewise the north Lleyn beaches have only a vestigial flora, the most extensive occurring at Porth-y-nant. Trevor has mainly a sandy beach but there is a narrow shingle fringe atop the beach by the derelict pier. Here scattered plants of Plantago coronopus and T. maritimum grow. The more protected north-west facing shingle at Aberdesach and Pontlyfni has a double ridge development and much more vegetation. This system continues north to Morfa Dinlle but public disturbance there and south of the Afon Llyfni have reduced the vegetation cover at those locations to occasional Atriplex plants.

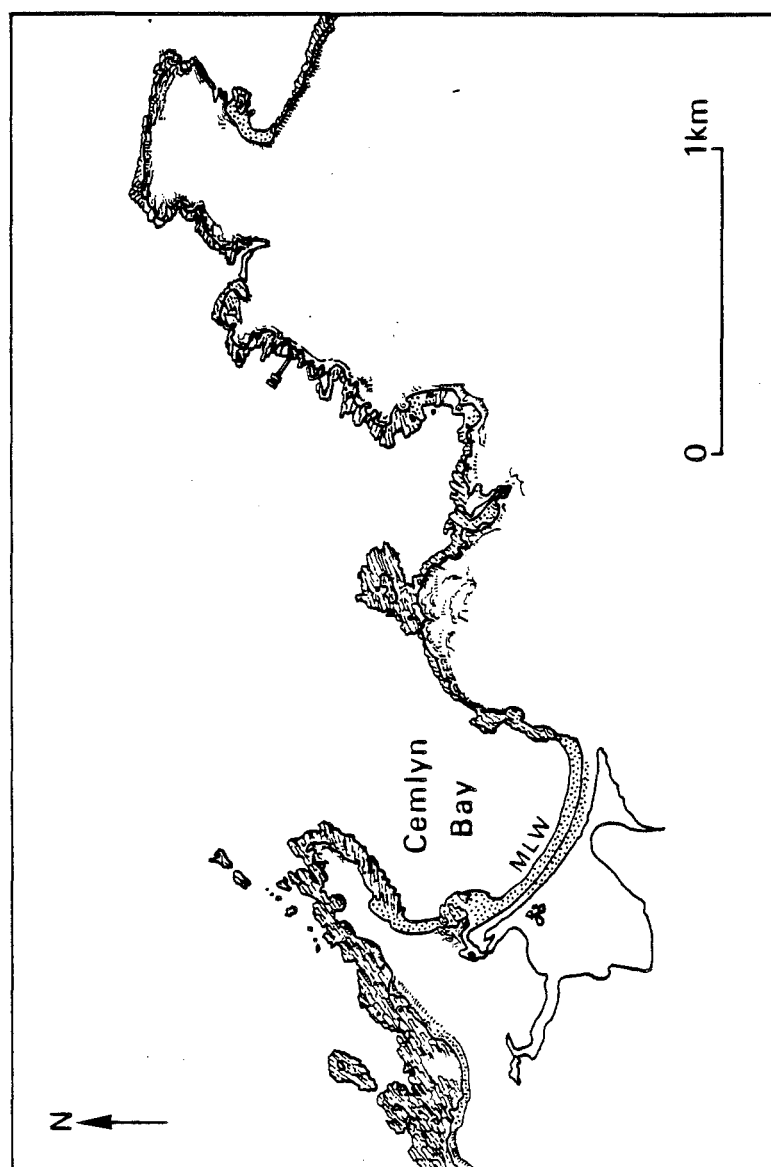
Typical Site

Cemlyn Bay, Anglesey. (North Wales Naturalists' Trust) SSSI, SH 331932

Cemlyn Bay (Fig. 9) is almost completely divided into two by a shingle bar which has a characteristic maritime flora. Landward of the bar there is a brackish pool linked to the sea by a weir. The bar consists of flat stones, up to 15cms diameter, (with most about 5cms), combined with very coarse sand. The bar is about 50m wide over most of its length increasing to 80m in places. At the two ends of the bar sand overlies the shingle to a depth of 20cm and is topped by peaty humus. The central section is shingle with some interstitial sand. This middle section is more active with occasional waves breaking over the bar, moving it landwards. There is relatively little human disturbance of this site and it is the best example in North Wales of a low sand content shingle beach.

In the middle section of the bar there are large quantities of Crambe maritima growing in 2-3 lines parallel to the shore along previous strandlines. In front of the Crambe there are annual growths of Atriplex spp. To the rear of the Crambe, patches of Silene maritima, Geranium robertianum and Beta maritima occur. This gives way to a Festuca rubra turf with Glaux maritima and Plantago maritima near the lagoon. The stable areas at either end of the bar support a richer but less typically 'shingle' vegetation.

Fig. 9 Cemlyn Bay, Anglesey



A very small sandy and shelly shingle spit projects into Red Wharfe Bay. Although this area is well-used by boat tourists, there is limited parking and the spit is relatively undisturbed. There is a rich flora including: Agrostis stolonifera, Amorphila arenaria, Atriplex glabriuscula, Atriplex patula, Beta maritima, Elymus farctus, Festuca rubra, Honkenya peploides, Leymus arenarius, Medicago lupulina, Plantago coronopus, Plantago maritima, Poa annua, Polygonum aviculare, Polygonum oxyspermum, Rumex crispus, Salsola kali, Sonchus asper and Tripleurospermum maritimum.

The Menai Straits shore has much inter-tidal shingle but little vegetated above high water mark whereas from Bangor eastwards to Llandudno, shingle is not a significant shore sediment.

Between Colwyn Bay and Abergele there is a long series of almost continuous fringing shingle beaches. The area faces north and is backed by an apposition bank (and a railway embankment) behind which the land rises to Carboniferous limestone cliffs. There are several beach ridges with pebbles almost entirely composed of local limestone and there is a significant matrix of limestone sand and gravel. This results in a rich calicolous flora. Typical plants of the open shingle are Glaucium flavum, Crambe maritima, Cakile maritima, Beta maritima and Eryngium maritimum. It is the only Welsh station for Mertensia maritima which grows with Diplotaxis muralis at the eastern end. Towards the rear of the system where more sand is incorporated in the shingle, Geranium robertianum and Sedum acre are the major components of the vegetation, with Honkenya peploides, Ononis repens, Carlina vulgaris, Eryngium maritimum, Picris echioides, Arabis hirsuta, Catapodium marinum and Rumex crispus also common.

The whole area is subject to considerable tourist pressure with vehicle pressure also high at the eastern end. Winter storms also severely modify this beach and affect vegetation distribution.

TABLE 5

SHINGLE STRUCTURES OF WALES

East Aberffrw	bar/ridge	none/silt	<u>Cybalaria muralis</u>
Pickleridge	ridge		<u>Polygonum oxyspermum</u>
Allt Wen	spit	sand	<u>Prunus spinosa</u>
Cemlyn Bay	bar	coarse sand	<u>Crambe maritima</u>
Llandulas	apposition banks	sand	<u>Mertensia maritima</u>

Although the Lancashire coast has little shingle, there is a stretch near Bolton-le-Sands where Glaucium flavum is common.

AREA 5 NORTH WEST

General Description

This area includes all the North-west Coast sites south of the Scottish Border but also includes the Inner Solway. The most important area of shingle centres in the South Walney and Foulney Island area (Fig. 10). Elsewhere there is little shingle, though on the Lancashire coast, a small stretch occurs near Bolton-le-Sands where Glaucium flavum occurs.

Typical Site

South Walney SSSI
and Foulney Is.
Cumbria Trust Reserve

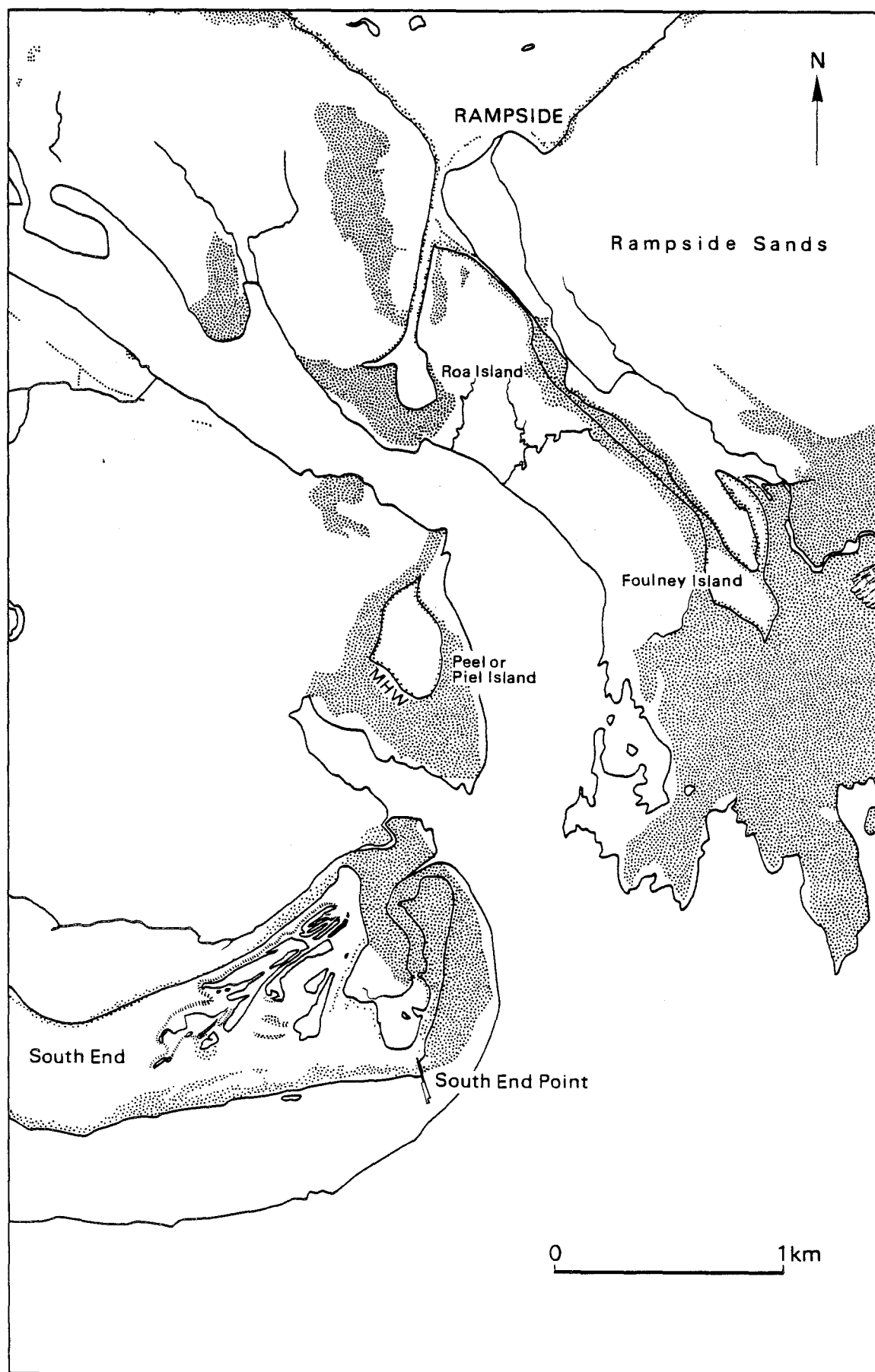
Cumbria
SD 220650

South Walney area is a diverse complex of sand dunes, sand flats and shingle. It contains the largest ground nesting colony of Herring and Lesser Black-backed Gulls in Europe and a fluctuating Tern population. The offshore shingle scars have noteworthy winter wildfowl populations. Access to the shingle spit is prohibited during the nesting season.

The major area of interest is the spit at the distal end of South End Haws. Here a wide variety of plants make this one of the richest shingle beach flora in Britain. The communities are most fully developed on the seaward side of the spit and along the west shore where the force of prevailing winds and waves is greatest. The strandline plant communities along parts of this unstable shoreline are considerably broader than those on the north-east shore. The spit consists almost entirely of strandline communities.

In the outermost zone, the high tide is marked by Atriplex spp. Inland this gives way to Tripleurospermum maritimum and Senecio viscosus. Where there is an admixture of sand Honkenya peploides is common, or in places Sedum acre. Lower inland areas influenced by salt water contain Atriplex littoralis and Spergularia malina. The highest parts of the spit are dominated by Festuca

Fig. 10 South Walney-Foulney Island Complex



rubra with Rumex crispus and Glaucium flavum. Where the main nesting area for gulls and eider ducks occurs there are zooplethismic communities dominated by Lolium perenne but with Echium vulgare, Hyoscyamus niger, Cirsium arvense and Carduus tenuiflorus also common.

The inland area of South End Haws has been extensively worked for gravel. The resultant "disturbed shingle" communities are dominated by ruderal taxa but include considerable spreads of Echium vulgare, Hyoscyamus niger and Verbascum thapsus. In damper areas Salix sp and Sambucus nigra have established.

In the past Crithmum maritimum and Mertensia maritima were found at South Walney. The latter was last seen in 1976.

On Foulney Island large inputs of seaweed and other organic remains enable dense strands of Crambe maritima, Rumex crispus and Silene maritima to grow on the back of the storm ridge. Further inland Sedum acre, Geranium robertianum, Cochlearia danica and Honkenya peploides grow on the finer shingle. The interior ridges of shingle have made an apposition bank on which a thin organic soil occurs. This contains Glaucium flavum, Lotus corniculatus, Myosotis discolor, Saxifraga granulata, Sonchus asper, Sonchus oleraceus, Armeria maritima, Vicia hirsuta, Vicia sylvatica and Anthriscus caucalis. The lower shingle 'hooks' or curved spits have a matrix of silt and have a more salt-tolerant flora including Suaeda maritima, Limonium vulgare, Halimione portulacoides and Festuca rubra.

The other sites are largely fringing beaches and not covered in the Great Britain survey.

The Inner Solway coast has a series of saltmarsh, sand and shingle beaches. The latter are mostly small fringing beaches with a sparse flora. Extensive shingle becomes more significant in Luce Bay where much of the west facing coast has undisturbed stretches of vegetated cobbles with prostrate scrub.

Table 6

SHINGLE STRUCTURES OF NORTH WESTERN ENGLAND

Walney Island	spits	sand	<u>Hyoscyamus niger</u>
Foulney Island	multiple ridge	none/sand	<u>Crambe maritima</u>
North Solway	multiple ridge	none	<u>Prunus spinosa</u>

AREA 6 SCOTLAND

A - West

The Scottish shingle sites are characterised, as with many other coastal habitats, by the absence of certain southern species such as Crambe maritima, Crithmum maritimum and Glaucium flavum whilst others such as Mertensia maritima and Ligusticum scoticum are found as replacements.

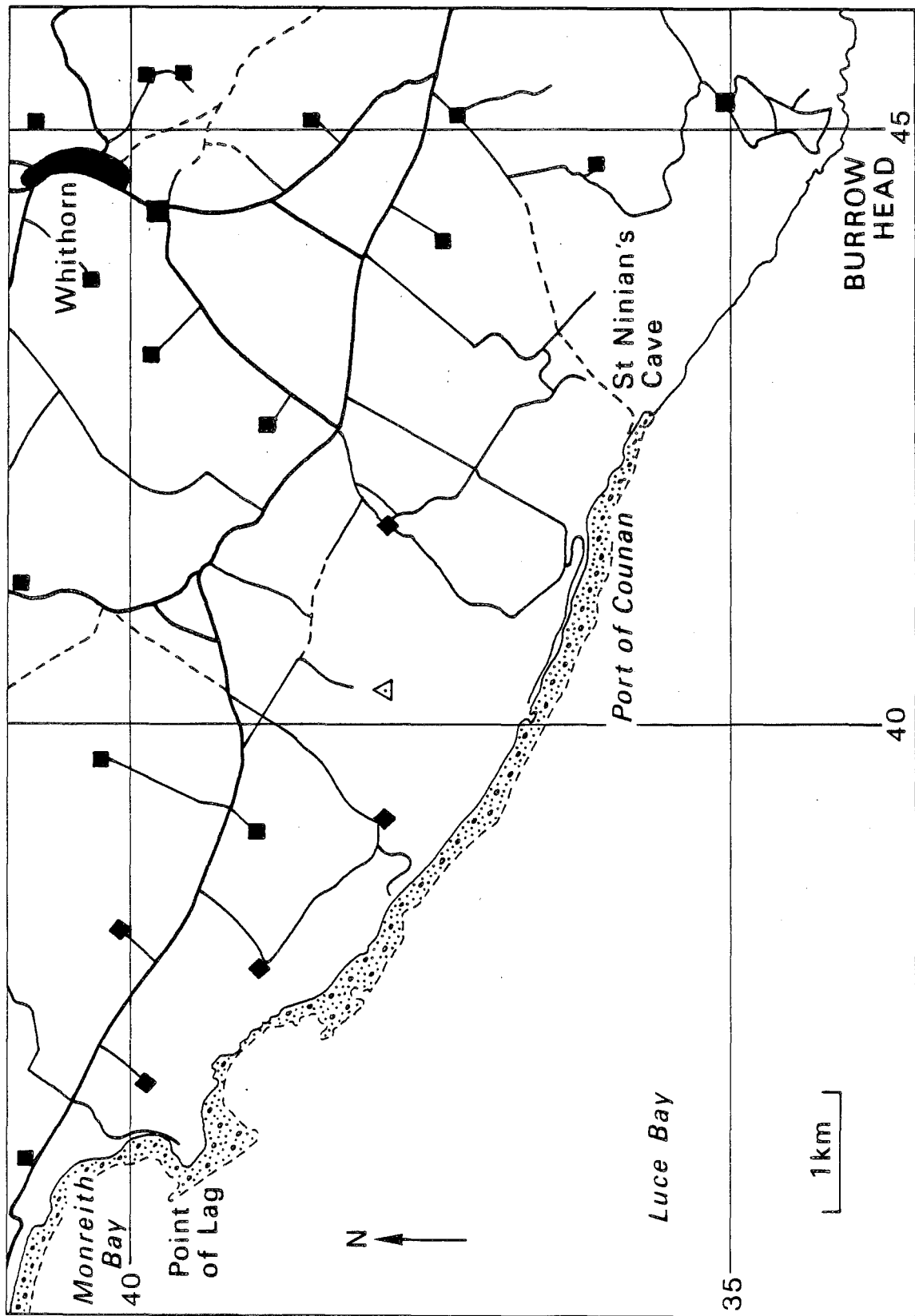
Distinct geographical zones can be identified, with the sites in the South and West being composed of extensive vegetated beaches or features associated with loch shores. The two exceptions are Ballantrae and Rhunahaorine, which are significant features on a national scale. Rhunahaorine in particular contains transitions to heathland and fits more closely with the sites in the North East.

Typical Sites

Point of Lag-St Ninians Cave, 418362 Wigtownshire

This stretch of coastline faces the exposed south-west (Fig. 11) It has a wide range of coastal habitats including vegetated shingle. The foreshore

Fig. 11 Point of Lag-St Ninian's Cove



comprises a ridge of shingle, gravel and cobbles which has been colonised in abundance by

<u>Atriplex prostrata</u>	<u>Geranium robertianum</u>
<u>Beta vulgaris ssp maritima</u>	<u>Glaucium flavum</u>
<u>Calystegia soldanella</u>	<u>Mertensia maritima</u>
<u>Carlina vulgaris</u>	<u>Raphanus maritima</u>
<u>Crambe maritima</u>	<u>Rumex crispus</u>
<u>Euphorbia paralias</u>	<u>Salsola kali</u>
<u>Euphorbia portlandica</u>	<u>Tripleurospermum maritimum</u>

In those areas where there is a considerable admixture of coarse sand in the shingle monocultures of Honkenya peploides occur on the foreshore. Where the backshore levels out as a raised beach there are carpets of Rosa pimpinellifolia overlying bryophytes, primarily Polytrichum sp, Pleurozium sp, and Rhytidiadelphus triquetrus. Other colonisers of this acid shingle heath include Sedum anglicum, Rubus fruticosus, Prunus spinosa and lichens.

Stinchar Shingles, Ballantrae, Ayrshire

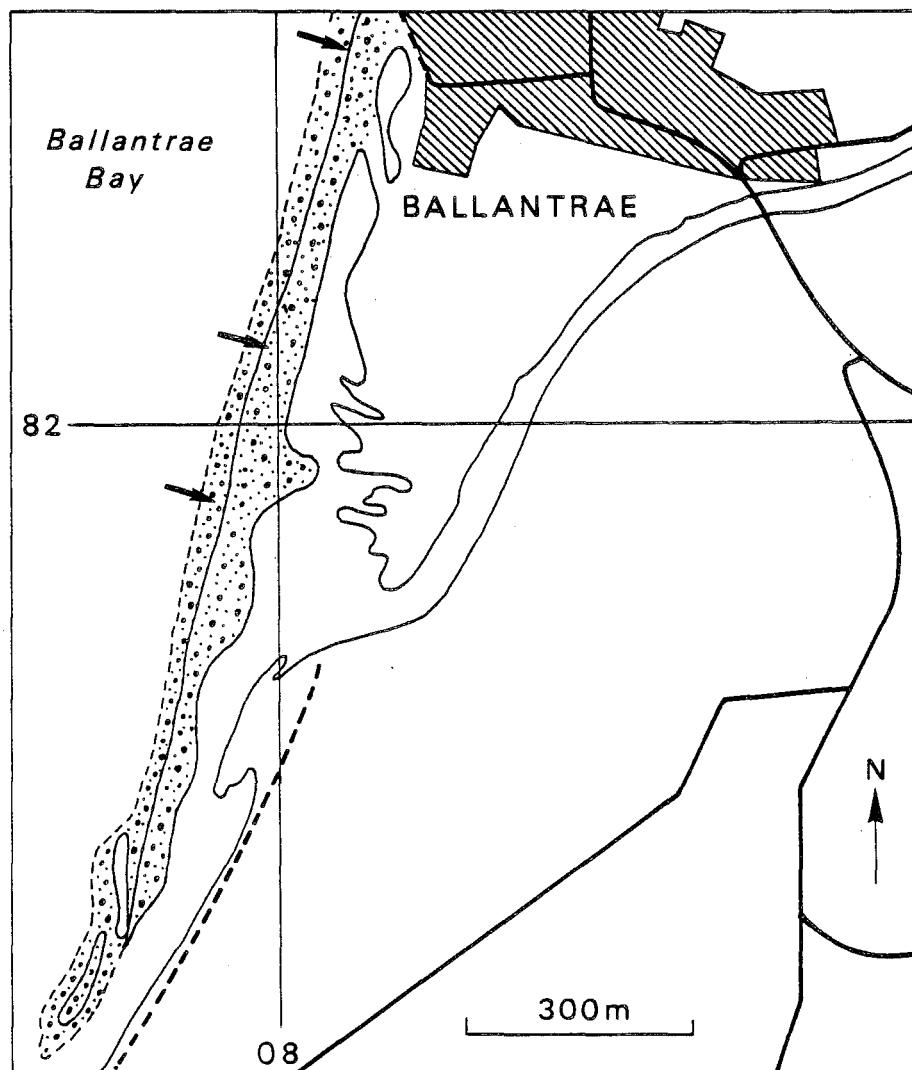
SSSI

NX078818

Scottish Wildlife Trust Reserve

This area (Fig. 12) lies at the mouth of the River Stinchar and extends to some 55 acres. The shingle consists almost entirely of fine-grained granite provided by the erosion of Ailsa Craig. Much of the area is highly mobile except for two recurves of shingle behind the main spit. It is a very exposed site but high rainfall, low summer temperatures and warm winters, coupled with a good supply of nutrients from tidal drift results in a surprisingly large flora.

Fig. 12 Stinchar Shingles, Ballantrae



The seaward shingle is largely bare but at about 30m inland scattered pioneers occur: Atriplex hastata, Tripleurospermum maritimum, Honkenya peploides, Rumex crispus and Silene maritima. Behind these Ammophila arenaria is present where sand occurs between the shingle. Elsewhere there is a good population of Mertensia maritima, with some plants over a metre in diameter.

Further inland both the pure and the sandy shingle has a Festuca rubra sward with Galium verum, Geranium molle and Bellis perennis. On the wider and more stable parts of the system semi-prostrate Sarothamnus scoparius and Ulex europaeus are present.

The landward side of the spit has a remarkable transition zone of strandline, shingle and saltmarsh species with inland seedlings from river debris adding to the confusion. Typically growing together are Puccinellia maritima, Plantago maritima, Agrostis stolonifera, Atriplex hastata, with seedlings of Acer pseudoplatanus, Crataegus monogyna, and Betula pubescens.

The older ridges unaffected by the influence of the sea are in part a sand-shingle mixture and have most of the species found on the outer-ridges. However, there are also several species indicating succession towards scrub including Rubus idaeus, Rosa canina agg, Rosa pimpinellifolia. This area is also used as a local dump and organic waste has resulted in large populations of nitrophiles and ruderals.

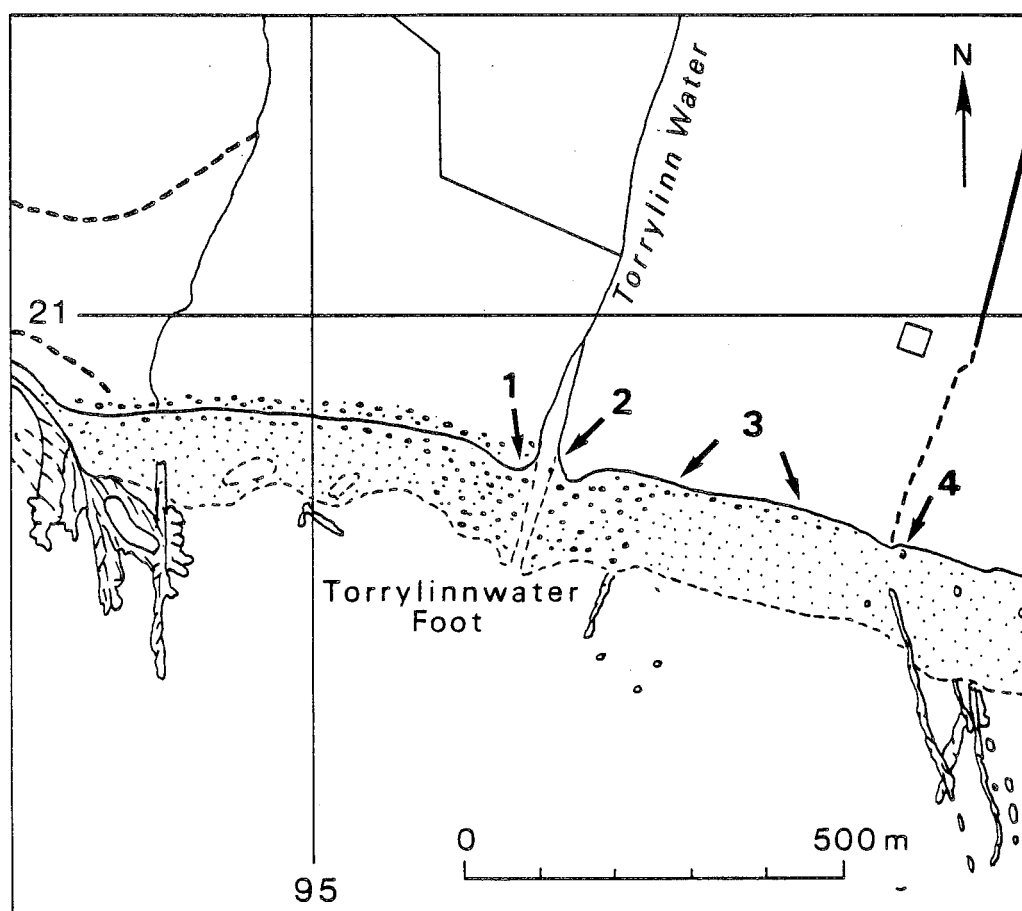
Torrylinwater Foot, Arran

SSSI

NR 956207

This stretch of cobble beach at the mouth of the Torrylinwater (Fig. 13) is typical of many on the Arran coast but here conditions are extremely suitable for Mertensia maritima. The population on this beach is probably the largest in southern West Scotland. The best population is west of the burnmouth where there is a continuous bed of approximately 250 Mertensia plants for 130m including many large rosettes in flower up to 2m in diameter, plus countless seedlings and plantlets. The shingle here is very coarse with

Fig. 13 Torrylinwater Foot, Arran



driftwood and other flotsam and jetsam. Associated species are Atriplex glabriuscula, Galium aparine, Elymus farctus, Rumex crispus and Tripleurospermum maritimum. Immediately east of the burn is another population of scattered rosettes of Mertensia growing in mixed shingle and gravel. This eastern population shows some damage from tourist disturbance but the area to the west of the burn is totally undisturbed.

B Orkney and Shetland

The nothern isles are very different from the rest of Britain in that the shingle sites are all small and have distinctive geomorphological characteristics. Most are generally formed when storm beaches cut off inlets or lochs, so they develop as single or double spits (houbs in Shetland, ayres in Orkney) often between islands, which retain at least one opening to the sea. See figures 14 and 15. These sites as with the Scilly Islands lie in very exposed high-energy coasts and consequently the shingle is composed of large sized pebbles.

Orkney has three SSSIs in which vegetated shingle is an important component: Waulkmill (HY37065), a south-facing inlet of Scapa Flow with a well-developed salt-marsh behind a stable shingle bar; Swarsquay (HY499097), with a double shingle ayre unique to Orkney; and the island of Copinsay (HY605015) which has an extensive storm beach on which there is a large colony of Mertensia maritima. Echnaloch in Burray and the Churchill Barrier also have extensive vegetated shingle.

Shingle beaches have a characteristic strandline of Atriplex glabriuscula and Tripleurospermum maritimum especially where there is a matrix of sand and decayed seaweed. Associated species are Silene maritima, Sonchus arvensis, Galium aparine and, rarely, Mertensia maritima. The backshore vegetation of shingle beaches is strongly influenced by adjacent land use. It may merge into other semi-natural vegetation, as in geos, but is more commonly dominated by coarse grasses e.g. Arrhenatherum elatius and Elymus repens, together with Heracleum sphondylium, Rumex crispus, Lathyrus pratensis, Potentilla

Fig. 14 Long Ayre, Scotland

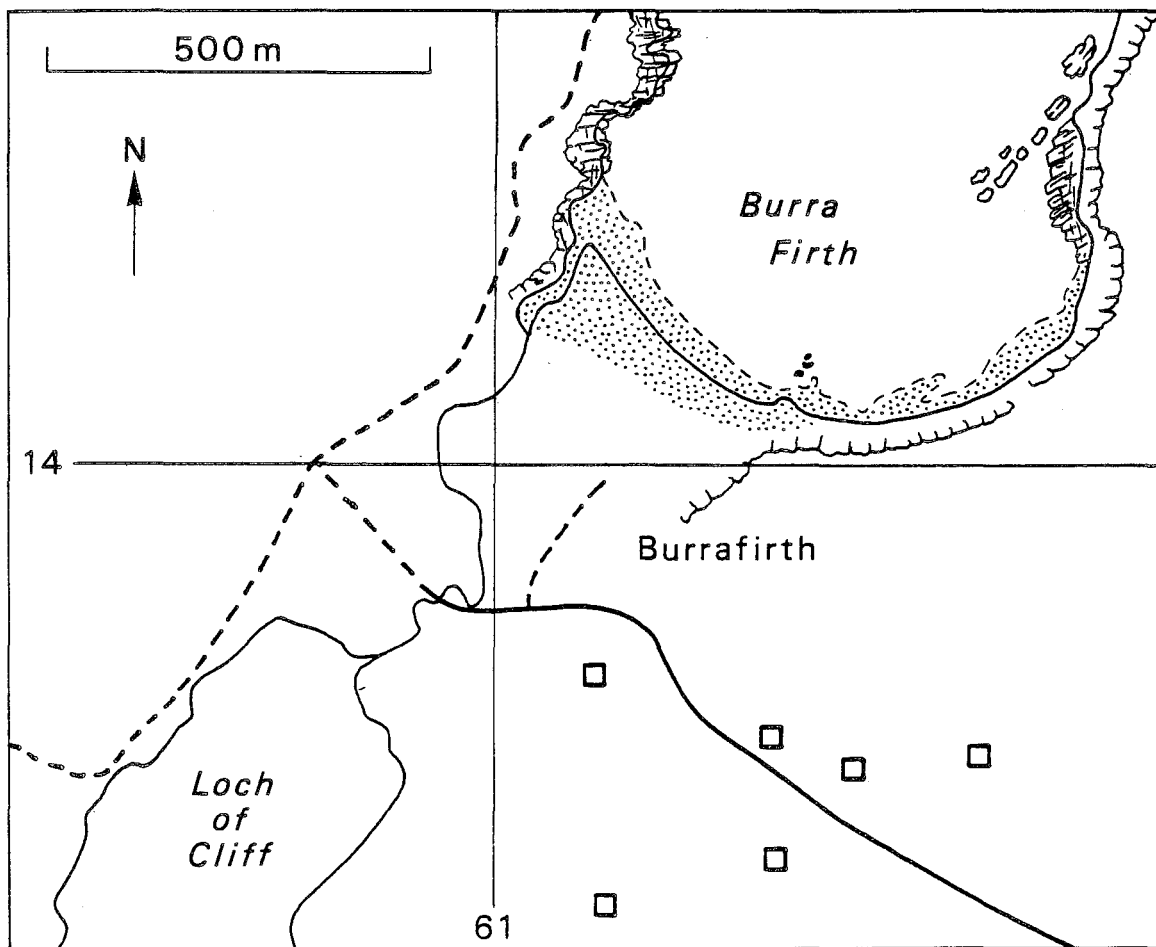
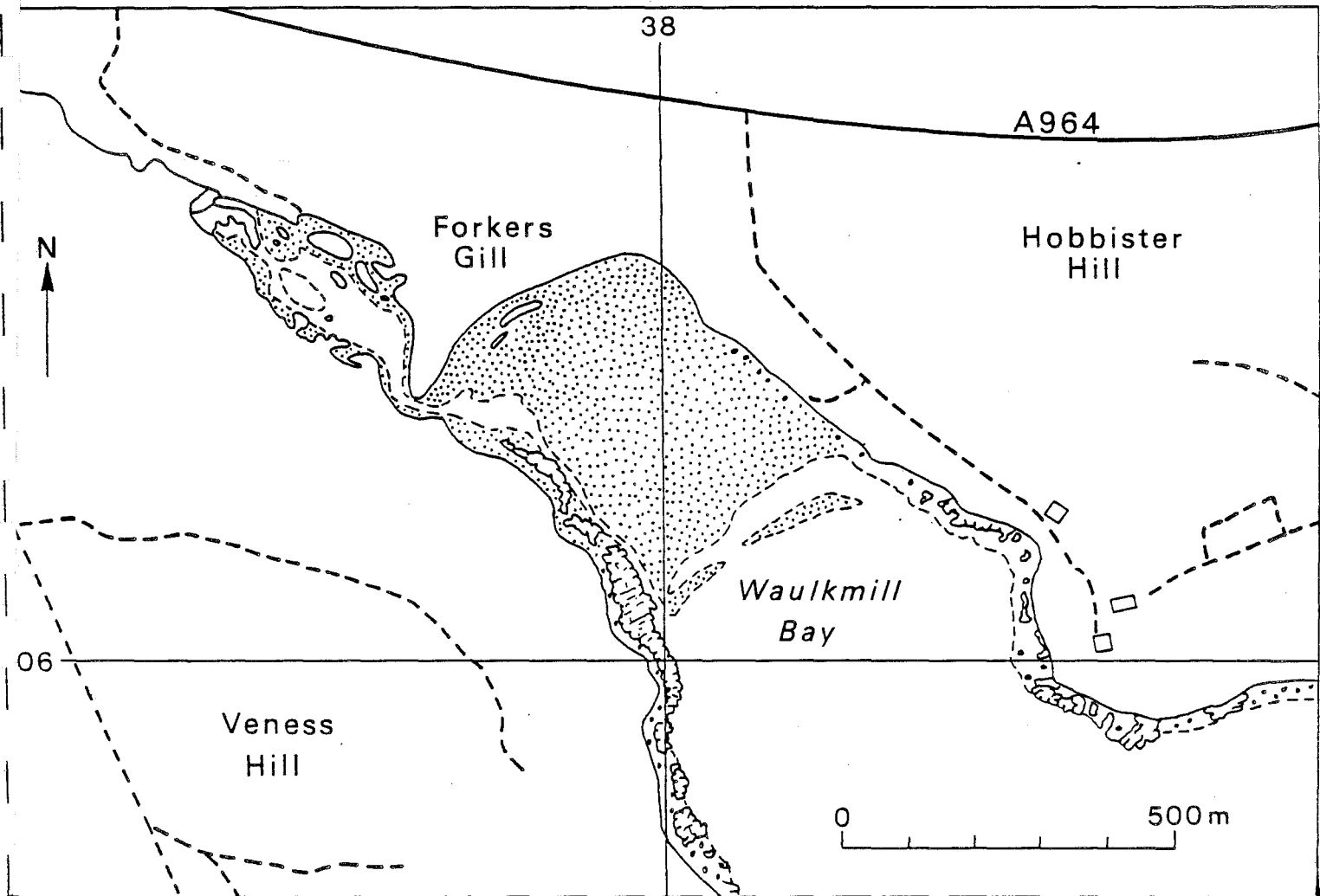


Fig. 15 Waulkmill Bay, Orkney



anserina and Galium aparine. Stabilised areas of shingle on spits and bars invariably include Festuca rubra, Elymus arenarius, Tripleurospermum maritimum, Atriplex glabriuscula and Potentilla anserina. Arrhenatherum elatius occurs in such areas occasionally.

Storm beaches composed of large cobbles or boulders of sandstone have a specialised vegetation which, in addition to the copious development of lichens, include Urtica dioica, Myosotis arvensis, Stellaria media, Ligusticum scoticum, Scutellaria galericulata and Armeria maritima.

Low rocky shores form 71% of the Orkney coastline (Mather et al 1974b). They include rock platform and areas of periodic accretion, together with areas of loose cobbles and boulders intermixed with outcrops of solid rock. Such areas carry a scattered flora of Tripleurospermum maritimum, Atriplex glabriuscula, Rumex crispus and Elymus arenarius, with a zone of Potentilla anserina along the back-shore. These rocky shores often have a contrast between relatively permanent strongly halophytic vegetation developed on the rock platforms, and the more rapidly changing areas subject to accretion which are characterised by annuals or other species capable of rapid colonisation.

C North East Scotland

This geographical area contains some of the best examples of shingle structures in Great Britain. Unlike the other major areas in the south east where there is a major influence on all sites by man's activities, the Culbin Shingle Bar is virtually completely natural (Fuller 1975). Of the other important sites, the shingle at Kingston is of national importance, though here afforestation and excavation have altered the surface over much of the site. Despite this it still retains natural and important vegetation, including transitions to saltmarsh.

Typical Sites

Kingston Shingles

This site (Fig. 16) is situated on the north-facing section of the Moray Firth and consists of an extensive series of raised apposition shingle ridges (127ha). Much of the site is vegetated although there are unvegetated shingle ridges inland which support only saxicolous lichen cover. This site forms the major part of the Speymouth vegetated shingle complex. The raised beach shingle is thought to have originated about 8,000 years ago at the same time as the Binn Mill Cliffs were being cut.

A storm bank of active, largely bare shingle bounds the top of the shore with a vegetated slack behind this. Overtopping of the shingle in storms has led to some movement of the bare shingle inland over the vegetated shingle.

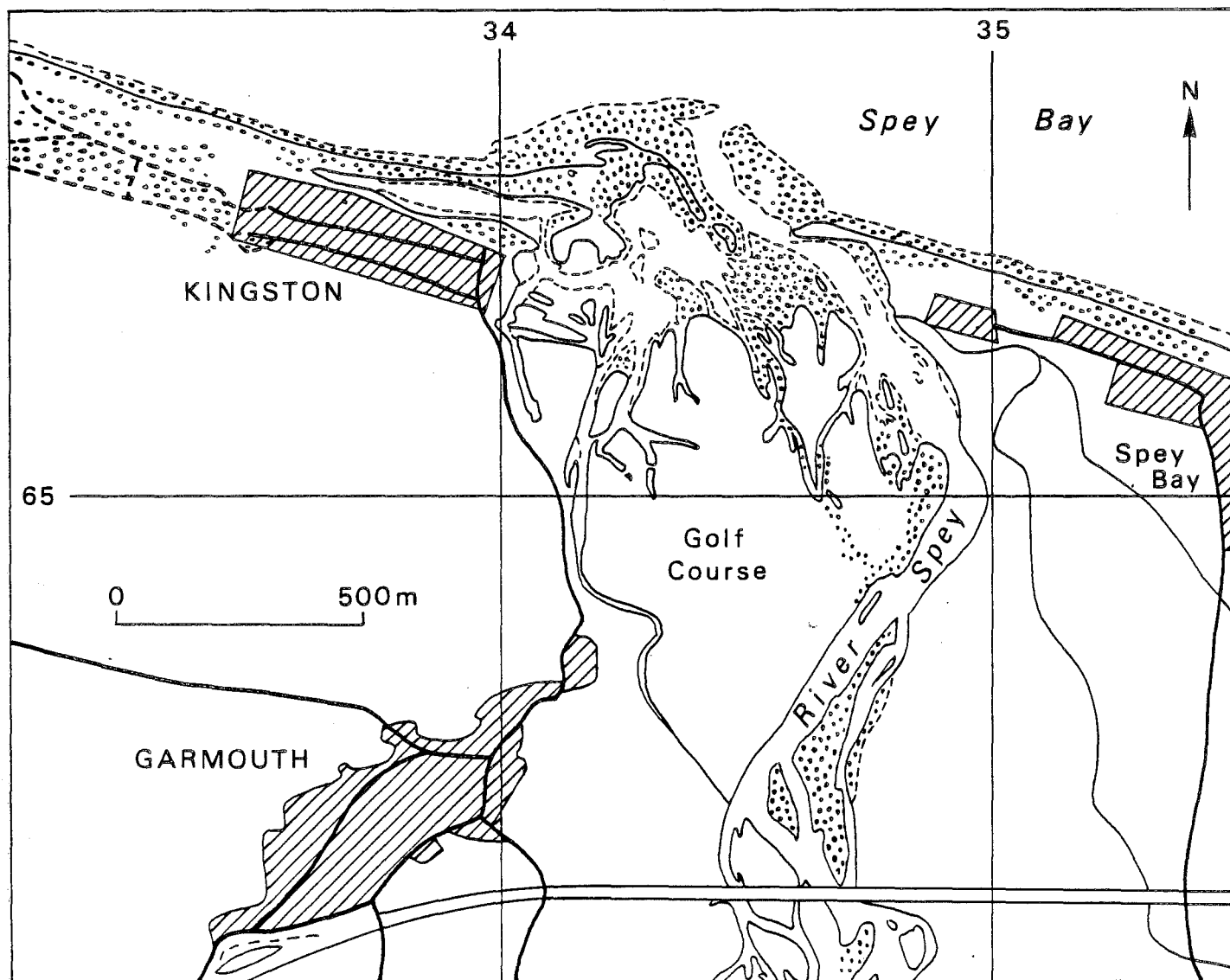
Extraction of shingle during the last War has led to the formation of damp lows on the raised beach which experience periodic flooding. A small stream (Stripe burn) runs through the centre of the site and drains into an almost permanently flooded hollow. At the back of the site there is additional flooding in the lows between the bare shingle ridges.

The western end of the site has been afforested with a fir plantation replacing the natural vegetation of the site, and an MOD rifle range has also caused clearance of vegetation in this area.

The presence of such a diverse range of different environments within the shingle habitat has led to the development of very varied floristic communities. Indeed this site is second only to Dungeness in Kent, in terms of its importance to the vegetated shingle resource in Britain today.

The very rich flora of this site may be broadly categorised into the following major communities: Ulex rubus scrub on raised areas; a Rosa pimpinellifolia/Erica cinerea/Cladonia rich community on drier parts of the excavated areas; Empetrum/Erica/Thymus/Festuca grassland in occasionally flooded areas. Phragmites/Equisetum reed beds; Salix/Betula/Carex carr in the poorly drained shingle lows; Cytisus/Erica/Calluna on drier areas; Salix repens/Juncus/Schoenus/Calliargon in particularly wet areas.

Fig. 16 Kingston Shingles



Culbin Bar

Culbin Bar (Fig. 17) is an offshore shingle bar situated west of the mouth of the Findhorn river. It is part of a complex system of sand dunes and shingle ridges covering some 30km and known as the Culbin Sands. The bar, however, is separated from the mainland system by up to one mile of intertidal sand flats and saltmarsh. It lies on a northeast to southwest axis extending 7km and attaining a maximum width of 300m.

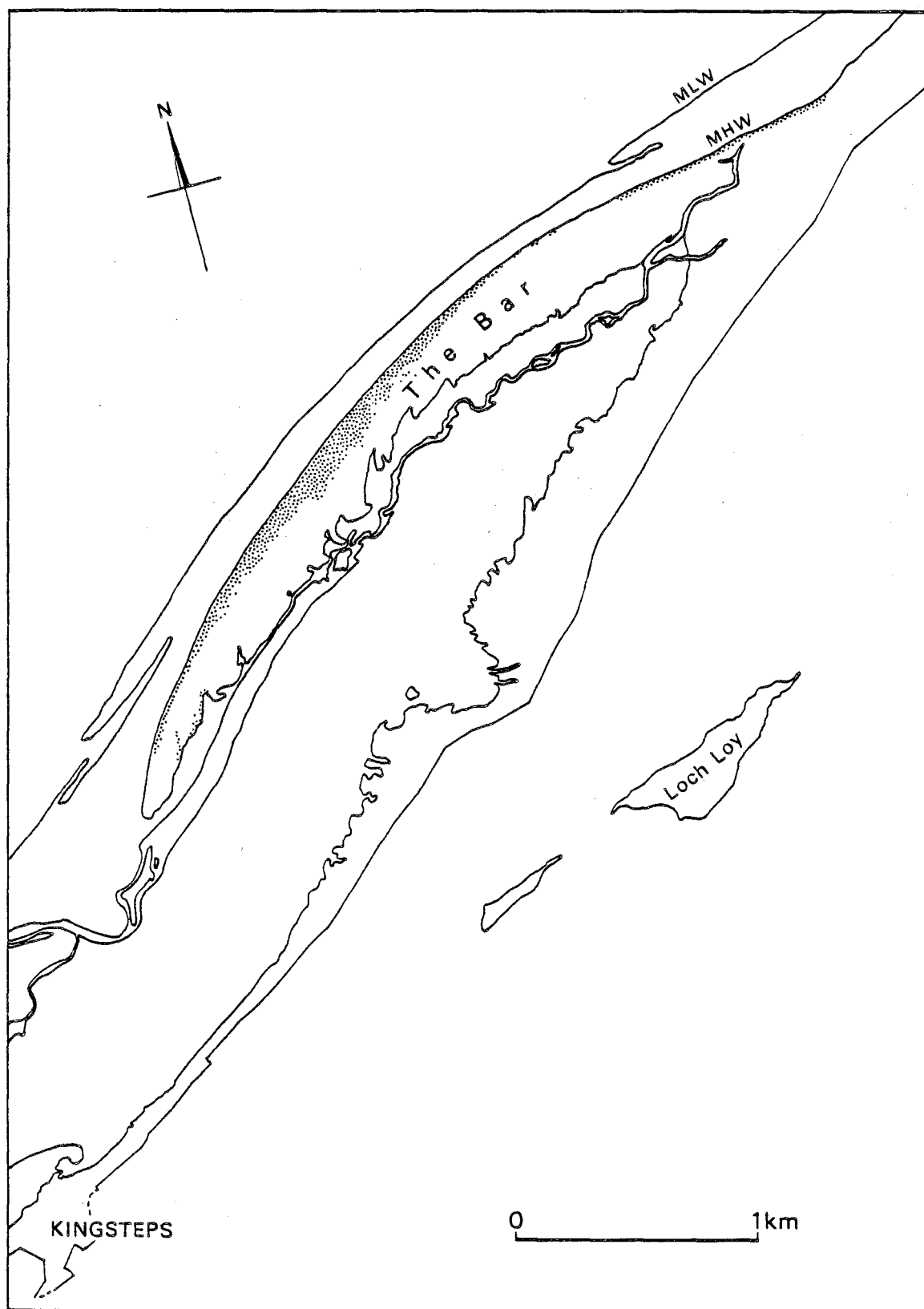
The bar comprises a complex series of shingle ridges with recurved laterals on the leeward edge. This shingle is sand-capped in parts, most notably on the leeward edge. Erosion of the eastern half of the bar has removed all visible shingle, leaving only the sand-capping which may reach up to 3m in height. The western end of the bar is actively prograding with varying amounts of wind-blown sand. It is this part of the bar which is of most significance to a study of shingle vegetation.

The presence of sand within the shingle matrix clearly influences the flora of the site with shingle/sand communities developing on the laterals. In addition this site also provides examples of saltmarsh/shingle communities around the leeward edge of the bar, particularly around the laterals.

The vegetation ranges from bare shingle with saxicolous lichen cover only, through to a herb-rich Festuca grassland with Lotus corniculatus, Vicia lathyroides and Violariviniiana. This then gives way to an Empetrum/Juniperus heathland on ridge tops which develops into a Calluna/Cladonia heathland and eventually into a Cytisus scrub with occasional Ulex, on the sandy laterals.

The nature of the vegetation on this site has been preserved by its isolation and the relative difficulty of access for the general public. There is one derelict building on the bar, but it is otherwise undisturbed.

Fig. 17 Culbin Bar



The eastern coast of Scotland has limited distribution of shingle beaches. One of the more interesting occurs at Strathbeg, Aberdeenshire (SSSI, 4ha shingle) where a paramaritime shingle shore along the border between loch and dunes has a series of clearly zoned rich communities, dominated by Deschampsia caespitosa and Polygonum amphibium. This lies inland of a series of dunes formed on the old shingle shoreline.

Further south shingle occurs at Barns Ness, East Lothian (SSSI).

TABLE 7

SHINGLE STRUCTURES OF SCOTLAND

Ballantrae	spit	none/sand	<u>Mertensia maritima</u>
Rhunahaorine	cusate foreland	sand	<u>Calluna/Empetrum</u>
West Arran	multiple ridge	none/sand	<u>Mertensia maritima</u>
Orkney	bars (ayres)	none/organic	<u>Mertensia maritima</u> <u>Ligusticum scoticum</u>
Shetland	bars (houbs)	none/organic/sand	<u>Mertensia maritima</u> <u>Ligusticum scoticum</u>
Whiteness	spit	sand	<u>Honkenya peploides</u>
Kingston	apposition beaches	none	<u>Calluna/Empetrum</u>
Culbin	spits/bars	none/sand	<u>Empetrum/Juniperus</u>
Aberdour	ridge	none/sand	<u>Mertensia maritima</u>

AREA 7 - NORTH EAST ENGLAND

In Northumberland there are small shingle fringing beaches at Cocklawburn, Lindisfarne and Newton-by-the-Sea. At Cocklawburn and Lindisfarne the shingle is very sandy and has a flora of Ammophila arenaria, Honkenya peploides and Ligusticum scoticum. The Newton shingle is more extensive including two small, offshore islets. The shingle is largely Whinstone with some limestone. Larger boulders with long-term stability are lichen encrusted with Caloplaca thallincola, Ramalina siliquosa, Ramalina subfarinacea and Xanthoria parietina. Where the shingle is smaller or mixed with sand a richer flora is present. This is quite nitrophillous because of nesting eider duck, oystercatcher, arctic tern and ringed plover. Species present include Ammophila arenaria, Atriplex lacinata, Atriplex patula, Armeria maritima, Carex otrubae, Cochlearia officinalis, Elymus pycnanthus, Galium aparine, Geranium sanguineum, Honkenya peploides, Leymus arenarius, Rumex crispus, Silene maritima, Solanum dulcamara, Sonchus arvensis, Tripleurospermum maritimum and Tussilago farfara.

The Durham coast is virtually bereft of shingle though in a few places accumulations of sea coal give an appearance of shingle. Hawthorn Dene for instance has Ligusticum scoticum growing in coaly shingle and sand. At Whitburn Steel there is a pseudo-raised beach with cobbles and sand on which there is an abundance of Carlina vulgaris.

Similarly Yorkshire is limited in coastal shingle habitats. Spurn Head does contain some very sandy vegetated shingle but at this site the most characteristic shingle species are found in the debris from concrete blocks that have been dumped in an attempt to stabilise the western side of the spit. Here Diploaxis muralis is common.

There are minor amounts of shingle on the Lincolnshire coast at Donna Nook and Saltfleetby, each with a vestigial flora. At Gibraltar Point the beach is shingly after storm conditions when pebbles from glacial deposits offshore are thrown up or uncovered, but sand rapidly accumulates over these areas. Beach ridges on the spit are very sandy shingle with a pioneer flora of Salsola kali, Cakile maritima and Atriplex laciniata.

The above descriptions represent a preliminary view based on personal knowledge of two of the author's. As indicated in the introduction, the NCC initiated a more detailed review of the major sites. Because of the lack of data on shingle vegetation contained within the National Vegetation Classification, it was decided to survey all sites using the NVC methodology. The next section of the report describes the results of the first year's work.

NATIONAL SHINGLE SURVEY

This survey has now been underway for just over eighteen months. During that time a review of existing information on coastal shingle in Great Britain has been conducted, and has resulted in the compilation of a shingle bibliography (Sneddon and Randall 1989). Information from the regions led to the identification of 60 potential sites shown on Figure 1. to be covered in the survey. During the first field season (summer 1988) thirteen sites were visited, seven on the East Anglian coast and six on the Moray Firth in Scotland. These sites included Kingston Shingles and Orfordness, two of the largest shingle sites in the country, after Dungeness. The data collected in the field has been entered onto computer and preliminary TWINSpan and TWINTAB analyses have been run. These have been sent to Lancaster University and will be used as the basis of the shingle section in the NVC. Individual reports are currently being prepared for each site visited. The survey's aims were twofold, firstly to establish a classification of shingle vegetation, and secondly to map the vegetation at each site. The data were collected in the form of species abundance within a 4x2m quadrat using the Domin scale. These were then entered onto a computer and TWINSpan and TWINTAB analyses run on them.

In the TWINSpan analysis the quadrats are grouped by reciprocal averaging and then indicator species are identified for each group of quadrats. The constancy values calculated by the TWINTAB package will eventually be used to identify each community in terms of its relationships with existing NVC categories. Previous work on shingle suggests that there will be close links with acid grassland and heath communities but it is unlikely that the categories would exactly match other community types given the combination of a maritime influence and the nature of the shingle substrate in modifying vegetation.

The preliminary run of TWINSpan on all data highlights the ability of the reciprocal averaging technique in identifying clear dichotomies in the data supplied, a function of its non-centred methodology (Noy Meir 1973, Hill et al 1974). Hence, where quadrats had been located in saltmarsh-related communities, (which frequently occur adjacent to shingle substrates, and had been sampled in order to facilitate comprehensive mapping of a site) they were

identified at the first level of ordination in the TWINSpan analysis to form the basis of the first dichotomy. Because this initial group of quadrats comprised a total of only 16 quadrats (containing only 8 species) it led to a rather skewed classification overall, resulting in the downweighting of the importance of the true shingle communities. As a result, many of the final groupings on the initial run of the classification (taken down to six levels of distinction) remain somewhat large with the largest category containing as many as 100 quadrats. Obviously this was hindering the interpretation of the data with regards to the shingle communities.

It should be noted that the specific aims of this project are to devise a working classification of shingle vegetation within a critique of the National Vegetation Classification. As such, it is important that emphasis be placed on the communities occupying the truly shingle habitat and that less emphasis be placed on those communities which reflect a clearly non-shingle habitat. With respect to shingle/saltmarsh and shingle/dune transitions, these may be important in the overall study of shingle communities and have, therefore, been included in the analysis with the proviso that they do not distort the final classification to any great extent.

As a result, therefore, a second run of analysis was conducted which excluded those quadrats which were identified as contributing to the saltmarsh categories of the original classification. In addition to the saltmarsh communities there were also sand dune communities identified in the initial classification. However, these were only identified at the fourth level of the hierarchy so it seems unlikely that they have a major impact on the overall classification.

The second TWINSpan analysis on the subset of the 1988 data, excluding the saltmarsh quadrats has produced a classification more applicable for the shingle habitat.

This classification highlights a major north/south trend in communities although it is interesting to note that there are also communities which appear to span the geographical range. The major geographical division becomes apparent at the third level of the hierarchy. It is at this level that certain northern communities, found only at the Scottish sites, emerge as a clearly

obvious unit. The classificatory grouping of quadrats across northern and southern sites is, perhaps, of more interest as it suggests that there are communities which result from factors other than those associated purely with geographical location such as climate, and which are more a function of abiotic factors such as substrate or fine matrix composition.

A closer investigation of the final classification units identified by the TWINSpan programme reveals many clearly recognisable communities which have been interpreted in the light of notes taken in the field.

The first level of division has separated the more open, pioneer communities from the mature communities characteristic of the more terrestrial shingle away from the foreshore. The most typical pioneer shingle communities, those dominated by Lathyrus japonicus and Crambe maritima are picked out at the sixth and final stage of the division. Given that the total number of quadrats in each category is 9 and 2 respectively, it would probably be more appropriate to agglomerate the two groups into one community. Indeed, further inspection of the quadrat composition reveals that this would be an acceptable procedure with Lathyrus japonicus as the key indicator species while Crambe maritima would be a preferential indicator which could be used to categorise a sub-community of the Lathyrus pioneer association. This community is truly pioneer in nature and is characteristic of the open foreshore, with much bare shingle and is very species poor with Lathyrus japonicus and/or Crambe maritima rarely in association with other species. As would be expected, this community is restricted to southern sites, reflecting the geographical range of Lathyrus japonicus.

Crambe maritima forms a major component of another pioneer community, but in this case it grows in association with Glaucium flavum and Cirsium arvense while Rumex crispus and Senecio viscosus are also common. This is a more closed community which is found on the less disturbed shingle beyond the storm crest. Glaucium flavum is, perhaps, less useful as an indicator of this community as it emerges as the single indicator (as identified by TWINSpan) for a further pioneer grouping which is similar to that outlined above but has been separated at the fifth level of division due to the absence of occasional arenicolous species. While Glaucium is the key indicator of this community, Rumex crispus may also be used as an additional indicator. This community is found across

several of the East Anglian sites and is the most common south eastern pioneer grouping. It may be more useful to consider the Glaucium/Crambe community as a sub-community of this more common grouping indicative of a more sandy substrate.

A typical sandy pioneer community also emerges at the final level of division; in this case Honkenya peploides and Ammophila arenaria are highlighted as the key indicators. Rumex crispus and Senecio viscosus are common associates indicating the shingle element of the community. This appears to be a robust unit incorporating 24 quadrats even at this final level of division. In addition, this community is found across northern and southern sites ranging from Sizewell to Culbin Island, indicating the important role of the sand as fine fraction in influencing the species composition of this community.

This level of the hierarchy also clearly defines several communities which display a marsh influence in terms of species composition at certain sites. The first of these is characterised by the presence of Atriplex littoralis, particularly in association with Senecio viscosus and also Suaeda maritima. This is, however, a relatively local community to Orfordness, found in a depression in the shingle where it has been excavated down to a level close to the underlying marsh sediments or at the marsh/shingle transitional areas. A further shingle/marsh group which is less pioneer in nature, also local to Orfordness, is an Agrostis stolonifera community, which is more closed than the previous category. This is, however, represented by only two quadrats and, as such, little emphasis should be placed on the community at this stage in the research, although it may become important as the classification is extended with further fieldwork.

The presence of communities which are obviously typical of other habitats such as sand dunes or saltmarshes would seem to lend support to the Chapman (1976) proposition that "there are no true shingle species and that all those plants which do occur have come from other habitats." However, these communities were identified in the field as offering different habitat conditions to those of a pure shingle and so have not been interpreted in this way. It should be borne in mind that those quadrats which were placed in obviously different, yet adjacent, habitats were excluded from this analysis

and so the quadrats used in this classification are predominantly those with a mean particle size greater than 2mm. This shingle component does appear to modify the communities to some degree, as they do not conform exactly to the pure sand or marsh equivalents, but rather tend towards these but with different constants.

Another pioneer community, representative of pure shingle and identified at the sixth level of division, is characterised by Rumex crispus and Sedum acre along with Beta maritima and Senecio viscosus as associated constants. This community incorporates 13 quadrats, which occur commonly in the southern sites but is also represented at Culbin in Scotland. It has been shown earlier that Rumex crispus is not unique to this community but this is the only group which has Rumex crispus as the key indicator in the absence of the more common shingle pioneer indicators such as Crambe or Glaucium.

Beta maritima is a common associate in a different pioneer-type community. The qualifier "type" has been used in this instance as this community is indicative of more inland areas than these communities discussed earlier which are found close to, if not at, the strandline. These inland areas have developed a flora following disturbance by Man in uncovering or producing areas of bare shingle and so the flora should be considered secondary in nature. The southern limit to this community may, therefore, reflect the increased likelihood of disturbance in the south where sites are generally subject to greater human pressures. Excavation has occurred in northern sites but has resulted in very different communities which seem to result from the depth of excavation which, as will be shown, leads to regular flooding of the areas, thus altering substantially the nature of the habitat.

Halimione portulacoides one of the key indicators of the southern community, illustrates the potential presence of marshy substrates under the shingle which has been excavated. Elymus pycnanthus and Silene maritima are also indicator species but it is the presence of Beta maritima in conjunction with these species which distinguishes this association.

Two groupings identified at the final level of the hierarchy, could usefully be considered as sub-communities of a wider Festuca rubra/Lathyrus japonicus community. This is a more mature community found in less immediately

maritime areas. The first sub-community, illustrated at Walberswick, has Elymus pycnanthus as a preferential indicator and as such it is not very clearly defined. The second variation, however, has Geranium robertianum as an indicator, along with the Festuca rubra and Lathyrus japonicus constants.

A major grouping evident at the fourth level of division in the hierarchy, is the open Arrhenatherum elatius grassland found at Orfordness (and also seen on a brief visit to Pagham Harbour). This community dominates the major part of the ness at Orfordness and there is little cover offered by the community with an average of 50% bare shingle in quadrats. While Arrhenatherum elatius is the major constituent of this community, it is commonly found in association with Silene maritima which is, in fact, identified by TWINSpan as an indicator in the largest of the sub-communities separated out at the final stage of the classification. Indicators of the other sub-communities are firstly Senecio jacobaea, which is characteristic of the next largest grouping. Of the remaining two Arrhenatherum sub-communities, one seems to resemble closely the Arrhenatherum-Silene group and it is unclear why the classification has separated these quadrats. The final sub-community, however, appears to illustrate a more closed and, perhaps, a more mature version of the broad Arrhenatherum elatius category and is characterised by the presence of lichen species, in particular Cladonia tenuis.

This grassland is not a truly pioneer community because it occupies vast areas which are relatively undisturbed and are also some distance from the shore, thus less maritime in nature. It could be considered an example of a pure shingle grassland of the south east where overall vegetation cover remains low due to the absence of fine material in the shingle and organic inputs either from terrestrial or marine sources.

Another community, which seems to develop on the more terrestrial southern shingle, but substantially different in character to that above, is the Holcus lanatus-Arrhenatherum elatius grassland which is more closed than the almost pure Arrhenatherum communities discussed above. Along with Holcus lanatus, Hypochoeris radicata and Senecio viscosus are indicator species with Arrhenatherum and Silene maritima as additional constants.

The remaining groupings on the positive side of the classification are rather small and seem to have been separated due to the dominance of a single species in each case - Lactuca serriola, Epilobium angustifolium and Senecio viscosus. Because of the size of the end groupings these categories should not be taken too literally and will not be adopted as key classification units at this stage in the research. Clearly, as the classification evolves over the subsequent field seasons these categories may develop into important units.

The major division on the opposite side of the final classification is between the wetter areas of vegetation encountered on the Scottish sites and the better drained communities which are spread across southern and northern sites.

As was mentioned earlier, certain communities were associated with areas on southern sites which had been excavated at some time in the past. Excavation is a common disturbance of shingle habitats and not unique to southern sites, although it may be more prevalent in the south. However, the excavation at Kingston, the major Scottish site surveyed in 1988, has been on such a scale as to lower a large area of the shingle to within inches of the summer water table. As a result, this area remains relatively wet for a shingle site and, indeed, is frequently flooded particularly in winter. This results in a very different collection of communities developing in this area, which, in some cases, might be more commonly associated with mires.

An immediately identifiable community which is not only found at Kingston, but also occurs at southern sites, is the Phragmites reed bed with Ranunculus flammula as an associate. While this category includes only two quadrats, the pure reed bed displays relatively little variability and is only included in this classification because of the occasional development of this distinct community in the shingle habitat.

Along the remaining "wetter" units there are three distinct communities identified at the fifth level of division and subsequently divided at the sixth. However, this final separation does not increase the clarity of the resulting communities, indeed, given the small number of quadrats involved, and the degree of variance, it would seem inappropriate to consider the final

categories as separate communities.

The first of the "wetter" communities is one which occupies the slack area immediately behind the storm ridge at Kingston. This area is lower than the general level of the shingle and is a natural feature, unlike the excavated area characterised by the main wetland communities. This slack community is mesotrophic and characterised by Salix repens/Schoenus nigrum and has Anthyllis vulneraria as an indicator species with Calliargon cuspidatum as a preferential species. This is a relatively species-rich community with Potentilla anserina and Potentilla erecta along with Empetrum nigrum. Indeed, Anthyllis and Calliargon may be used to divide the community to a further level, but this does not appear to be a useful division at this stage in the research.

A similar community, and one which could be considered a sub-community, along with that described above, of a more general wetland association has Betula pubescens as a discriminating indicator species. The broader community has Salix repens and Calliargon cuspidatum as constants, but it is the dwarfed Betula which separates it from the earlier community. It is interesting to note that this community, which has developed in an area which was excavated to a lower level than the natural damp slack, should support a similar community. However, these quadrats have been identified as a separate community from those around them, and field notes show that there was a mosaic patterning in this area and the Betula community identified here corresponds to the slightly raised areas. This highlights the importance of microtopography in influencing the development of vegetation. The presence of Betula pubescens would seem to conflict with the generally damp nature of this community, but it may be that the raised nature of the mosaic patches allows for this and has enabled the establishment of Betula which has invaded from the nearby drier areas supporting this species.

The more widespread community in which the above mosaic exists, is a damp slack community with indicator species Schoenus nigrum and Campyllium stellaria and characterised by the constant presence of Salix repens. Phragmites and Carex paniculata are also found in this association. While this community (identified at the fifth level of the hierarchy) is relatively robust containing 11 quadrats, it should be emphasised that in the broader context of a national shingle survey, this community is unlikely to be of wider applicability as it is currently unique to Kingston which is, in itself, somewhat atypical having been excavated to this level. It may be that this community represents a mature climax of the northern damp communities, which will be found less well developed on smaller northern sites, particularly the generally wetter western sites. Clearly, this will become apparent during the course of the next season's fieldwork.

Another community which is unique to Kingston and a function of its size and general lack of disturbance (other than the one excavated area), is the Salix cinerea woodland which has developed in the lows between shingle ridges (often bare) at the rear of the site. While much has been made of the possibility of Ilex aquifolium woodland being the climax for Dungeness, and potentially of all shingle sites, it would appear that Salix cinerea fulfils this role at Kingston and perhaps other northern sites. This woodland community may be divided into two sub-communities characterised by indicators Hypogymnia physodes and Parmelia fulcata respectively. Closer inspection of the species composition of these communities, in conjunction with field notes, indicates that the two sub-communities represent the extremes of a moisture gradient from the drier Salix cinerea woodland, as indicated by Hypogymnia physodes and the absence of any clear understorey layer, other than bryophyte species such as Dicranum scoparium or Eurynchium praelongum, to the contrasting relatively species rich, wetter, mesotrophic community as characterised by Deschampsia caespitosa, Equisetum arvensis, Parmelia fulcata and Angelica sylvaticus. The most extreme version of this sub-community has open water to a depth of approximately 20cm (when surveyed in late summer/early autumn).

The remaining communities may be divided broadly into mature grassland or heathland communities. In many cases the grassland communities are found

across both northern and southern sites but, perhaps not surprisingly, the heathland communities are restricted to northern sites.

Within the grassland communities there are two communities which appear to be indicative of relatively wet conditions. The first is characterised by the indicators Holcus lanatus and Juncus effusus with Festuca rubra as an additional constant. Elymus repens or Elymus pycnanthus, along with Agrostis stolonifera may also occur in this community. This division is relatively robust, covering 16 quadrats and is found mainly in the south at Walberswick-Dunwich but also at Kingston in Scotland. Juncus effusus works in this case as the character of the wetter conditions than would normally be associated with the shingle habitat. The second community is a more developed equivalent of the transitional saltmarsh/shingle pioneer community. This mature community is characterised by the following saltmarsh species - Plantago maritima, Armeria maritima and Limonium vulgaris. These species are commonly found in association with Festuca rubra and Elymus pycnanthus and less often with Halimione portulacoides. This community spans the geographical range of sites and commonly develops in low-lying areas as with the pioneer communities described earlier, but is found inland and as such is less maritime in nature. It may be, therefore, that this represents the more mature development of the original pioneer community. Clearly, a pure shingle substrate is very free-draining and unless found in conjunction with sand will not retain moisture to any great extent (Fuller 1987). It is not surprising then that in areas which are poorly drained due to presence of finer material either within the shingle matrix or underlying it very different communities will occur. The grouping described above is more akin to a saltmarsh community but it only emerges as a clearly separate grouping at the sixth and final level of the classification hierarchy and hence shows some resemblance to the pure shingle communities. This degree of homogeneity has led to the inclusion of these quadrats in the final analysis as they are not distorting the classification to any great extent.

In addition to the saltmarsh/shingle communities there is also evidence that the sand/shingle pioneer communities develop into more mature grasslands. Two grassland communities in particular display sandy elements in terms of species composition. The first is a Festuca rubra/Poa pratensis grassland with Sedum acre and Plantago coronopus as indicator species. This community is

particularly common at southern sites within a limited northern applicability at present. It is usually found in areas which are not subject to direct maritime influences. This category is one of the most widespread, incorporating over 60 quadrats at the final level of division. It may be useful, therefore, to divide this and group to one more level in order to test the homogeneity of this community.

The second sand/grassland community is separated from the first by the presence of Ammophila arenaria and Agrostis stolonifera as frequent associates, along with Vicia lathyroides and Lotus corniculatus. This seems to be a relatively mature community, with emphasis placed on Peltigera canina as the key indicator species for this group. Here too, the number of quadrats in the final category (50) suggests that further analysis may be required to test its inherent stability as a community. There is a southern component to this community but in this case it seems to have greater relevance to northern sites. This category offers a high degree of cover with no bare shingle or soil in quadrats, and is indicative of stable, undisturbed sites containing a highly developed lichen flora.

A separate Holcus lanatus grass community has been divided off in this part of the classification. It has Holcus, Agrostis capillaris and, once again, Peltigera canina as constants but in this instance Vicia lathyroides emerges as the major indicator species. Investigation of the quadrats falling into this category displays the northern nature of the group which is found at Culbin and Whiteness Head, both relatively sandy sites. It would appear, therefore, that this represents the northern Holcus sub-community compared with the southern version of the same overall community. The distinguishing feature of the northern version is the presence of Agrostis capillaris, Epilobium angustifolium and Senecio jacobaea.

Festuca rubra and Hypochoeris radicata are the constants defining a southern grassland community which supports two additional sub-communities. The Festuca/Hypochoeris grassland community is apparent at the sixth level of division. Plantago lanceolata and Tortula ruraliformis are also indicators of this association. The presence of Silene maritima and Arrhenatherum elatius, as frequent associates, appears to have led to the division of this community from the two sub-communities. However, it would seem that this should be

considered the major community as this is the larger group, containing 35 quadrats, is also southern in distribution, and contains the major constant species of the other categories. Thus, it is most appropriate to consider this the major community.

Of the two sub-communities, one is defined by the constant presence of Aira praecox and Eurynchium praelongum with Achillea millefolium as the indicator species. The second sub-group is characterised by the almost constant presence of Holcus lanatus and Cladonia coniocrae while Tortula ruraliformis acts as the key discriminator of this Festuca/Hypochoeris sub-community.

One of the grassland communities appears to be a different, and perhaps mature, version of the Arrhenatherum-Silene community discussed earlier to Orfordness. The difference between the two communities appears to be the presence of Rumex acetosella and Hypnum cupressiforme as constants with Dicranum scoparium, Cladonia impexa, Cladonia crispata, Cladonia verticilliata and Cerastium semidecandrum as frequent associates. It is a slightly more developed version of the earlier community and seems to have been separated in the classification due to this maturity and also the occasional presence of Festuca rubra.

Of the remaining eight communities, the majority are heathland communities, which generally occur on inland areas. However, in some cases, where there is active erosion eg. Whiteness Head, these communities are now near or at the seaward margin although there does not appear to have been any modification to the communities due to this increased maritime influence.

One heathland category is site specific to Littleferry in Scotland and is characterised by Cladonia impexa and Cladonia arbuscula along with Hyclomium splendens as constants. Indeed, Hyclomium splendens and Galium verum are identified as indicator species for this community, while Festuca ovina and Calluna vulgaris are also constants. This is a good example of the broader Calluna/Cladonia heathland category indicative of well-drained, northern shingle. This broader category also has Calluna vulgaris, Festuca rubra and Hypogymnia physodes as preferential indicators along with Cladonia impexa as a constant. This closed Calluna heathland community, containing 70 quadrats, is

the largest of the end categories identified by TWINSpan and is common to all northern sites. A visual inspection of the TWINSpan output suggests that this group displays a high degree of homogeneity despite the large number of quadrats. It would, however, bear further analysis to confirm the stability of this final category.

Three other heath-type communities are identified at the sixth level of the hierarchy, but in this case they are Ulex europaeus based. Once again, they all display a northern distribution.

The first of these is an ericaceous acid heathland, with Ulex europaeus, Anthoxanthum odoratum and Erica cinerea emerging as indicator species and with Erica tetralix as an occasional addition to the heathland species. This is a suitably robust category containing 34 quadrats.

Ulex europaeus is found in association with Rosa pimpinellifolia in a community distinguished by the indicator species Hypnum cupressiforme, Festuca rubra and Hypochoeris radicata. This may represent a northern progression from the Festuca/Hypochoeris grassland community.

The final heathland category is a mature Ulex europaeus dominated community. This is a very species poor community, due to the successful competition and dominance by Ulex europaeus, which then effectively excludes many other species, by providing almost 100% ground cover, thus inhibiting light to the ground layer. As a result Eurynchium praelongum is often the only associate. However, this community may also support some grass species eg. Agrostis capillaris, Festuca rubra, Holcus lanatus or Arrhenatherum elatius where cover is less than total.

Another community, unique to the north is a woodland community characterised by Rosa pimpinellifolia in association with Salix cinerea, Evernia prunastri and Hypogymnia physodes.

The final community is a herb rich grassland characterised by Festuca rubra, Arrhenatherum elatius or Holcus lanatus as the graminiferous component, but it is the presence of Polygala vulgaris and Pseudoscleropodium purum which distinguishes it from other northern grasslands.

Having identified and refined the classification, it will be used as the basis for future fieldwork where these broad categories will be used as the main classificatory units, wherever possible. Where communities are identified in the field which do not fit exactly into this classification, they will be noted as potential sub-communities within this broad framework. Where new communities occur which do not readily key out to those already identified, these will be added to the existing classification. Thus, a comprehensive classification will evolve over the course of the three-year study.

The first year's fieldwork schedule covered sites on the east coast of England and Scotland. They have, therefore, provided a good north-south range of potential shingle communities, which provides a suitable basis for the production of preliminary classification units. In addition to the geographical range of sites, the first field season covered two of the major sites in the country - Orfordness and Kingston shingles. These provide a complete range of communities, from pioneer stands nearest the sea through to stable, closed, mature communities on the older parts of the shingle structures. Clearly, this increases the general stability of the classification, although there will obviously be new communities added with the inclusion of west coast data.

During 1989-1991 (when the final report is due), this study will complete the survey of the remaining sites, analyse the data and produce an updated classification. After the third year of fieldwork, individual site reports will be produced for each location surveyed.

Conclusion

These results represent a preliminary review of the vegetation of the major shingle sites in Great Britain. Although the NCC is commissioning a detailed study of all these sites, it was felt appropriate to provide an interim statement. From these results it can be seen that there are few significant areas of major terrestrial coastal shingle deposits in Great Britain. Many of these have important and unusual examples of vegetation and data from Dungeness suggests they are also important for invertebrates.

The long history of exploitation, particularly in the south-east, has left some sites with little or no remaining interest (eg. The Crumbles), whilst others like Dungeness, though severely disturbed, are still of paramount importance.

A detailed knowledge of these sites is important.

1. To identify the best examples of geomorphological structures, vegetation and crucial communities.
2. In planning for conservation.

These elements could be even more important if predictions of sea-level rise are accurate. Because of their low-lying nature and relatively recent origin, they may provide a significant reserve of information of past history. In addition some sites, particularly Culbin Shingle Bar for example, are showing signs of erosion, which may be greater than in the past. This site, which is naturally moving westwards is smaller now than it was at the time of the survey reported in Fuller (1975). If this trend can be correlated with sea-level rise then shingle shorelines and beaches may, if adequately monitored, provide an important measure of rates of change.

This survey provides one element in the monitoring programme by establishing a base line against which change can be judged at least in so far as the zonal sequence of vegetation is concerned. A change here could be the precursor of more rapid erosional activity .

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