**Guidelines for the Selection of biological SSSIs**

**Part 2: Detailed guidelines for habitats and species groups**

# Chapter 1a Coastlands (coastal saltmarsh, sand dune, machair, shingle, and maritime cliff and slopes, habitats)

Authors

Rees, S., Angus, S., Creer, J., Lewis, H. & Mills, R.

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## Cover note

This chapter updates and replaces the previous *Coastlands* SSSI selection guidelines chapter (NCC 1989). It was prepared by Sue Rees, Rachael Mills (Natural England), Stewart Angus (Scottish Natural Heritage), Julie Creer and Heather Lewis (Natural Resources Wales) with input from other country agency specialists, in particular Nikki Hiorns (Natural England), Paul Brazier, Nicola Rimington and Gabrielle Wyn (Natural Resources Wales). It provides guidance for use in selecting coastal habitat sites throughout Great Britain to recommend for notification as biological SSSIs. The chapter should be used in conjunction with Part 1 of the SSSI selection guidelines (Bainbridge *et al.* 2013), which details the overarching rationale, operational approach and criteria for selection of SSSIs and other relevant habitat or species chapters, some of which are cross-referenced. See Part 1 section 1.5 for an explanation of the relationship with ASSIs in Northern Ireland.

The main changes from the previous version are:

- amendment of the selection criteria to reflect changes to Part 1, including the need to take account of ecological coherence, ecosystem services concepts and future climate change scenarios in site selection;
- updating of the habitat selection units (NVC or equivalents), where relevant, to reflect the final published version of the maritime habitats NVC or shingle classification (Rodwell 2000; Sneddon & Randall 1993) and making clear that updated classifications should be used if they are developed in future, for example as recommended in Rodwell *et al.* (2000);
- highlighting principles to promote incorporation of wider coastal processes into site selection;
- highlighting the importance of transitional zones with other habitats, ephemeral elements such as naturally occurring bare ground, and their role in providing niches for rare or uncommon species;
- to ensure that the dynamics of coastal habitats (as set out in Bainbridge *et al.* 2013, section 8.7), ongoing coastal change and the supporting coastal processes are more clearly set out for the purpose of boundary definition and feature selection, in particular to reflect the likely changes as a result of climate change, coastal evolution and coastal management decisions;
- highlighting the potential value of habitats that evolve naturally or result from restoration of coastal processes and ensuring that evidence is provided to support each case for selection. This is in line with section 5.2 (Bainbridge *et al.* 2013) requiring potential value to be an intrinsic part of site selection (also set out in sections 5.12.1 and 5.12.2);
- the chapter only covers selection guidelines for saltmarshes, sand dunes, machair, shingle and maritime cliff and slopes, including where these have transitions to other habitats, but the revised annex of selection units indicates a wider range of vegetation types that can occur in these environments;
- indicates cross-references to other chapters, specifically marine and saline lagoon sub-chapters, grassland, heathland and relevant species;
- stresses the limited extent of many coastal habitats and restricted distribution of some plant communities which support the adoption of a critical standards approach for most coastal habitat types; and
- clarity on using the Lowland Grassland, Lowland Heathland guidelines and relevant wetland guidelines for selection of inland forms of sand dunes and saltmarsh, which are not covered in this chapter.

This chapter has been subjected to appropriate levels of evidence quality assurance. It is compliant with the JNCC Evidence Quality Assurance Policy 2014 and has been subjected to external peer review by Paul Corbett, Northern Ireland Environment Agency.

## 1 Introduction

1.1 The coastal environment results from interactions between dynamic physical processes, maritime exposure, tidal inundation, sediment movement and a range of species tolerant of the resulting conditions. Geology and coastal geomorphology form the building blocks for the development of coastal habitats on both sedimentary and cliffed coastlines (May & Hansom 2003). The coastal habitat types covered by this chapter that arise from these interactions, combined with human activities (for example on machair), are:

- Coastal saltmarshes;
- Coastal sand dunes;
- Machair;
- Coastal vegetated shingle; and
- Maritime cliff and slopes.

These guidelines provide the basis for selection of SSSIs for these coastal habitat features.

1.2 These habitat types show considerable variation and different degrees of maritime influence[1]. Mosaics and transitions are common between coastal habitats and with other maritime, terrestrial and freshwater systems. Interactions between species and physical processes at the coast result in a series of habitats that are some of the most natural and least modified to be found in Great Britain. This wide variation, whilst providing niches for species or uncommon plant associations, does set challenges for setting selection criteria. Many of the principles set out in the revised Part 1 of the guidelines (Bainbridge *et al.* 2013) are relevant to these coastal habitats, such as those in sections 7 and 9 covering mosaics and ecotones. The concept of **naturalness** is a key aspect for site selection (Bainbridge *et al.* 2013, section 5.9). The role of functioning coastal processes also means that such habitats, with some exceptions, are difficult to recreate artificially which is considered as a key measure of **fragility** (Bainbridge *et al.* 2013, section 5.5). The coast is an environment where special interest is not fixed in time and space (Bainbridge *et al.* 2013, section 2.11).

1.3 1.3 Vascular plants dominate coastal vegetation, although non-vascular plants are important elements of some types, such as encrusting lichens on shingle and free-living fucoids in some saltmarshes (Rodwell 2000; Haynes 2016). Vegetation coverage can vary, sometimes seasonally and may not provide 100% plant cover. The National Vegetation Classification (NVC) or equivalent classifications (Rodwell 1991, 1992, 1995, 2000; Sneddon & Randall 1993; Ferry *et al.* 1990; Dargie 2000) indicate where more open plant communities occur in mosaics with patches of naturally bare rock, boulder clay, sand or other sediment surfaces. As such, naturally bare surfaces should be considered as part of the habitat. For example, bare sand on beaches forms a critical element of a sand dune system, with sand exchanged between the beach and dunes by wave and wind action. Sand is eroded from dunes to the beach during storms, but gradually returns over time (Psuty 2004). Within dune systems, naturally bare sand is a key element of the habitat. Other causes of bare surfaces are infrequent saline inundation, deposition of organic tidal debris or erosion and accretion sequences. Understanding how vegetation responds to these processes is essential when developing evidence to support site selection and boundary definition.

[1] Maritime influence is described in Ratcliffe (1977) as: **Maritime**: strong and direct influence of sea with markedly saline soils. **Sub-maritime**: less direct effect of sea with soils still more saline than those inland. **Para-maritime**: zone in which special climatic conditions of sea coast are influential but soils not saline and halophytes not present (NB this can relate to the influence of the underlying sediment such as shingle, sand or silt, and the microclimatic conditions of the coast).

1.4 **Diversity** of plant communities is variable and, as explained above, vegetation can sometimes be sparse or ephemeral. The coast provides the only suitable locations for many plants and plant communities (Webb *et al.* 2010; Rodwell 2000). Although diversity is a key criterion for site selection (5.8.1 of Bainbridge *et al.* 2013), those coastal habitats of naturally lower diversity, or which comprise just a few species in transitional or successional phases when compared to other habitats, should always be considered for site selection. There are also more widespread plant species in these habitats that have coastal ecotypes. Some plant species are of conservation interest in their own right.

1.5 Many vascular plant species of saltmarsh, dune, shingle and cliff habitats are highly adapted to maritime environments, tolerant of salinity, tidal inundation, exposure, nutrient stress and drought. These adaptations contribute to the ecosystem services provided by the coast (Jones *et al.* 2011).

1.6 All coastal environments have variable topography derived largely from coastal processes, and this is an indicator of **naturalness**. Topography ranges from gently sloping intertidal areas, to low-lying dune slacks, parallel shingle ridge patterns to steep or sloping cliff faces. In all cases, there is a change in elevation from landward to seaward, but there can be a 'back slope' from cliff tops or dunes. Sand dune topography can be altered by wind blow, resulting in undulations of ridges and hollows, sometimes sloping down to landward. There are functional relationships between different elements of the habitat, reflected in mobile species making use of different niches at different times or as the habitats evolve over time. Successional phases are considered in section 5.9.1 of Bainbridge *et al.* (2013) as being indicative of naturalness. One example of this is the vegetation succession in sand dunes, described as the 'psammosere' (Packham & Willis 1997). Coastal habitats can also undergo cyclical change when vegetation re-establishes after storms or other natural changes. Transitions to other habitats such as saline lagoons, intertidal mudflats and sandflats, freshwater wetlands and grassland or heathland habitats can all occur, and wider coastal landscapes will also include embanked coastal grazing marshes on estuary fringes. A more unusual transition is that of estuarine saltmarsh grading into trees or scrub, as found in parts of south and southwest England.

1.7 The need for grazing, cutting or other management to maintain certain stages of vegetation can be less critical than for open terrestrial habitats. Maritime exposure, salinity, flooding and sediment processes influence development of climax vegetation. Coastal habitats therefore comprise a range of successional and transitional stages, sometimes with ephemeral vegetation, and which may go through repeated cycles of change driven by environmental conditions, but often combined with active management, for example in sand dunes and machair.

1.8 Coasts provide important supporting habitats for internationally important numbers of wintering, breeding and passage birds. Selection guidelines for birds are provided in Chapter 17 (Drewitt *et al.* 2015). Coastal habitats can also be important for other species groups, in particular, bryophytes, lichens, fungi, invertebrates, as well as for scarce and declining vascular plants and the SSSI Selection Guidelines for these taxa should be applied as necessary. Where possible, site selection should indicate spatially where coastal habitats are included mainly as supporting habitat for species and/or where they qualify as habitat in their own right.

1.9 Selection of sites for coastal features needs to take particular account of other habitats with a functional relationship through coastal processes. These include marine habitats (estuaries, intertidal rock, intertidal sediment, lagoons, seagrass *etc*), defined by biotopes as described in the Marine Habitat Classification for Britain and Ireland v15.03 (JNCC 2015) and which are set out in the SSSI Guidelines Chapters 1b and 1c. In addition, lowland heathland, lowland grassland, woodland, freshwater habitats and a range of species can be found in association with coastal environments, often as a maritime form of the 'typical' NVC community. These can be described as 'para-maritime' (see footnote 1). Some species may have a distribution linked to coastal areas, such as *Scilla verna*. Soft cliff and shingle systems in particular can have mosaics of non-maritime habitat types and open ground reflecting physical processes and hydrology, and vegetation composition may not be a close fit with NVC types. Where coastal SSSIs are immediately adjacent to transitional or para-maritime communities, these should be included with maritime habitats, where these have a limited inland extent. However, where adjacent semi-natural habitats (e.g. heathland, grassland, woodland, mires) are extensive and extend some distance inland, they should be evaluated using the relevant guidelines.

1.10 Coastal Grazing Marsh was included within the 1989 'Coastlands' chapter. It is not included in this revised update as the main reasons for SSSI selection would be on species grounds (see relevant SSSI Guidelines Chapters on vascular plants, birds (Drewitt *et al.* 2015), invertebrates or for the species conservation value of associated ditch systems (see Chapter 6, section 5.2). Saltmarsh NVC communities can occasionally occur as fragments in unimproved Coastal Grazing Marsh resulting from relict influences of saline sediments following land claim, or by infrequent inundation or saline percolation into low-lying land. Whilst plant communities can reflect those of upper saltmarshes they do not receive the tidal inundation that defines coastal saltmarshes and may not persist as salinity decreases. Where these communities do occur, they could be considered for selection, using the appropriate chapter, along with other grazing marsh features if they were unusual examples.

1.11 Inland forms of sand dunes and saltmarsh are not covered in this chapter. Dune grassland on inland sites is covered by the Lowland grassland chapter (Jefferson *et al.* 2014) and inland dune heathland (e.g. as in Breckland) is covered by the Lowland Heathland guidelines (Alonso *et al.* 2018).

1.12 The natural variability of the coast means that each case will need to take account of the site-level evidence, alongside the guiding principles set out in Bainbridge *et al.* (2013), especially the issue of **ecological coherence** and **potential value**. The guidelines do not form final or exact criteria but assist selection decisions. Knowledge of coastal habitats has increased since 1989, especially how changes occur in response to environmental and human influences. Site selection and boundary definition should take account of short- and longer-term dynamics and how these are influenced by coastal processes, storm events or a change in coastal management policy.

1.13 There is a strong emphasis in Bainbridge *et al.* (2013) to enable SSSIs to cope with dynamic change and to use '**potential value**' as outlined in Section 5.12 of that publication. The implications of climate change for the coast mean that the need for adaptation and morphological evolution should be taken account of in selection and management of coastal SSSIs, such as regular review of boundaries to address predicted or actual coastal evolution and habitat creation, where feasible, designed to maintain the overall resource. These guidelines will also need to be used with expert judgement and understanding of ecosystem dynamics, applied with rigour and supported by available evidence and data. A suggested time-frame to consider change would be at least 20-30 or even 50 years ahead and to set boundaries with these time frames in mind. This links into predictions of coastal change used in flood and erosion risk management planning (Defra 2006).

1.14 Areas of Search (AoS) are explained in Section 4.13 (Bainbridge *et al.* 2013). These provide a conceptual framework that should reflect natural variation in climate, topography, geology, soils and also land use and to help spread the distribution of the SSSI network. At the coast, other factors such as degree of maritime exposure, aspect and coastal processes also provide a strong influence. The process of identifying sites for selection for coastal habitat features may, in some cases, require a degree of flexibility between countries as to how the AoS framework is applied. The following factors will influence the way in which AoS are used:

- coastal processes operate at different scales to most administrative boundaries;
- terrestrial biogeographical areas (such as NCAs in England) may not coincide with coastal sediment cell boundaries at the coast;
- AoS for marine site selection are based on coastal sediment cells (Figure 1) which may be preferable to use for saltmarsh selection alongside other marine features;
- coastal habitats are not evenly distributed across AoS, with some areas predominantly important for one habitat type (e.g. machair in the Outer Hebrides, or cliffs in Cornwall) and the presence of outliers away from the main concentration; and
- selection of sites where one AoS may have a high proportion of the country or GB extent.

There are no rules set for the maximum or minimum extent of coastal habitats to include in SSSIs within each AoS: the area selected will reflect not just the total in that AoS, but the country and British context. Note should also be taken of the approach to ‘extensive habitats’ in Section 8.8 of Bainbridge *et al.* (2013).

In all instances the principles for site evaluation set out in Bainbridge *et al.* (2013), (especially Sections 5 to 9) should be applied, taking account of the habitat within the AoS as well as its wider extent. For each habitat type, the sections in this chapter build on those principles.

Part 1 section 4.16 also emphasises that AoS boundaries should not be used to artificially cut off site boundaries (Bainbridge *et al.* 2013). A habitat feature which straddles AoS boundaries (including country boundaries) must be assessed as a whole and site boundaries drawn appropriately, with supporting information clearly stating the approach taken.

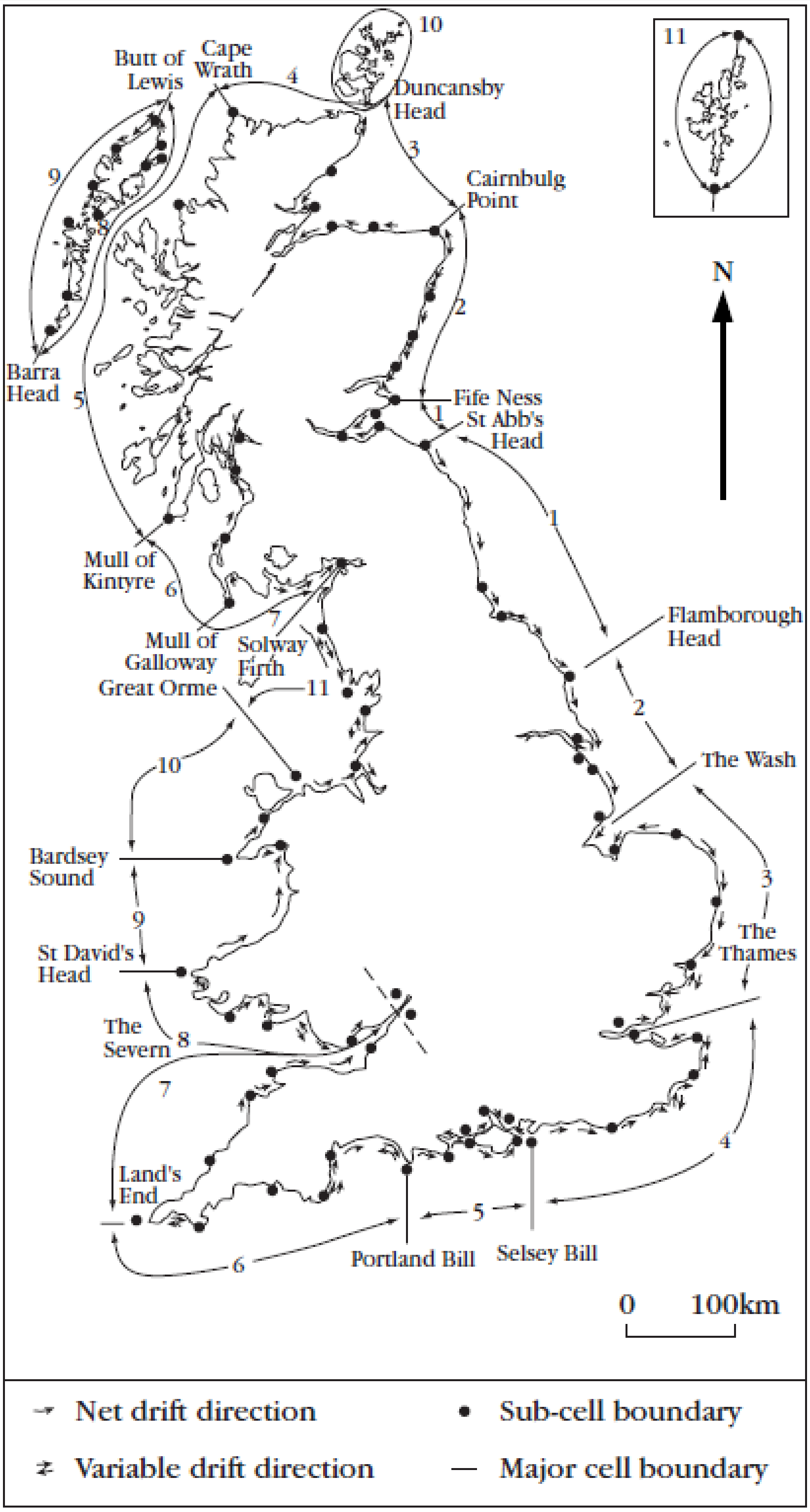


**Figure 1**. Areas of Search for selection of SSSI for marine features as shown in May and Hansom (2003), based on the major coastal cell boundaries for inshore areas of England and Wales (Motyka & Brampton 1993) and for Scotland (HR Wallingford 1997; Ramsay & Brampton 2000). The Isles of Scilly are considered as a separate cell in the relevant Shoreline Management Plan.

# 2 Coastal habitat types

Coastal habitats fall into four main categories as described briefly below (sand dunes and machair are considered together, although machair is a complex of habitats). There is a range of literature on these habitats and only key references are included here. Vegetation communities (selection units) and recommendations for each are provided in the separate Annex 1 of this chapter, including corresponding Habitats Directive Annex I habitats.

## 2.1 Saltmarshes

Of the habitats covered in this chapter, saltmarshes are probably the most extensive coastal habitat type in Britain (Table 1), but limited to less than 2000km of the coastline (Burd 1989). Most of the British resource is in England (Table 1). Sites have stands of vegetation ranging in size from just a few square metres to several thousand hectares, reflecting the different types of location these occur in, from small loch-head marshes to extensive areas in larger estuaries and bays. Saltmarsh vegetation patterns and succession are underpinned by sedimentary and tidal processes which influence the pattern and development of vegetation (May & Hansom 2003). Saltmarshes develop when halophytic plants colonise sheltered areas of fine-grained sediment (mud and sand) when it is exposed at low tide. Low current velocities and limited wave action allow sediment to accrete vertically, leading to vegetation establishment. A pre-marsh stage, comprising a film of diatoms or microalgae, stabilises the sediment surface (Underwood 2000). Saltmarsh vegetation is usually present in a series of zones reflecting the frequency and duration of tidal inundation. Lower elevation areas are covered more frequently by the sea and for longer periods than saltmarsh at a higher elevation nearer the land. Plant communities are made up of a diverse range of annual and perennial species: many are true halophytes (salt tolerant) confined to the habitat. Plants with a more widespread distribution also occur in the medium to higher marsh levels. Species composition is also a factor of physical and management factors, and there can be marked regional differences in saltmarsh types (Adam 1978; McLeod *et al.* 2008; Boorman 2003; Rodwell 2000).

Variation in vegetation community types reflects the maturity of the saltmarsh system, sediment type, geographical location, the frequency and duration of tidal inundation and grazing or other management (McLeod *et al.* 2008) and degree of freshwater influence. The lower (i.e. seaward) levels are characteristically species-poor, largely an open sward of a few pioneer species, mainly annuals. Landwards, perennial species and grasses become more frequent. The higher elevation saltmarsh vegetation is usually more diverse especially where there are unobstructed transitions to other natural or semi-natural habitats such as sand dune or freshwater marsh and where saline influence is more limited. These communities and the complex topography in the form of creeks, pans or variations in elevation provide habitat for plants, fish, invertebrates and both wintering and breeding birds in both the exposed and flooded states. The position and extent of saltmarsh zones will vary naturally over time in response to coastal processes, but it will also respond to human influences. Dating of sediments indicates that some existing saltmarshes in England started to form over 4000 years ago (May & Hansom 2003), whereas others are more recent, developing in response to natural or human modifications to estuary form.

Saltmarshes exist in a sequence with adjoining mudflats and, where present, intertidal seagrass communities. There are four types of saltmarsh listed in Annex I of the

Habitats Directive[2], and these can also be sub-features of the 'Estuaries' and 'Large Shallow Inlets and Bays' Annex I types. These latter two habitat complexes are addressed in the marine sub-chapter (Brazier *et al.* 2019).

**Table 1**. Indicative extent of broad habitats (hectares or kilometres) in Great Britain derived from UKNEA (Jones *et al.* 2011) and a range of other sources. (*excludes machair dune). See individual habitat sections for more detail of variation within these broad habitats[3].

| | **Coastal Saltmarsh (ha)** | **Coastal Sand dunes (ha)** | **Machair (ha)** | **Coastal Vegetated Shingle (ha)** | **Maritime Cliff and Slope (km)** |
|---|---|---|---|---|---|
| **England** | 32,462 | 11,987 | | 5,023 | 1,082 |
| **Scotland** | 5,623 | 15,022* | 11,680 | 1,169 | 2,450 |
| **Wales** | 7,345 | 8,101 | | 110 | 522 |
| **Total** | **45,430** | **35,110** | **11,680** | **6,302** | **4,054** |

## 2.2 Sand dunes and machair

Coastal sand dunes and machair together have a British extent of approximately 46,790ha. They are represented in all countries, with all machair found in Scotland (Table 1). Most systems are long-established and formed after the last ice age as sea levels changed and sea bed sediments were re-worked by tides and winds (May & Hansom 2003). Blown sand was subsequently stabilised by vegetation. There are some more recent systems with current topography only a few hundred years old (Pye 2007). Processes of change are still underway today, with older surfaces buried by more recent deposition or exposed by erosion. Blown sand systems therefore help to provide a record of environmental change.

Coastal dunes develop on beaches where sand particles (0.2–2mm grain size) blown from the intertidal beach plain are deposited above the tideline and are then colonised by strandline vegetation and dune-building grasses (Packham & Willis 1997). Dunes may be stable, eroding or accreting (Pye 2007).

Typically, phases of mobility driven by coastal dynamics result in a dune system with a sequence of dune ridges, usually more active towards the sea, although the amount of active succession is quite rare, with only a few sites prograding seawards. Wind speed, sand mobility and salt-spray impacts have less influence as distance from the sea increases. The free-draining and naturally nutrient-poor dune soils support specialised vegetation. When the beach sediment budget is positive, blown sand trapped by tidal debris and dune-building plants, create new foredunes which accrete upwards and outwards. As a result, foredunes increase in height providing shelter to sand that has already been deposited, leading to succession with more diverse vegetation on a series of increasingly stable ridges of varying height and form. Within dune systems, wind can scour bare sand down to the water table; the exposed damp sand is colonised by a characteristic plant assemblage including wetland species, creating low-lying dune slacks: seasonal wetlands, flooded in winter and often with high botanical diversity. Slacks can also occur where a new dune ridge forms to seaward, trapping a low-lying area that is initially brackish, but which eventually is only influenced by freshwater.

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[2] H1310 *Salicornia* and other annuals colonising mud and sand; H1320 *Spartina* swards; H1330 Atlantic Saltmeadows; H1420 Mediterranean and thermos-Atlantic halophilus scrub (Commission of European Communities 2013).

[3] 'Habitat area figures for each country are based on a range of sources which may have been updated by more recent studies. As such these are indicative only to provide context. For more recent data contact the relevant Country Agency'.

On the drier ridges dune grassland predominates, with dune heath on a few acidic sites. Mature native dune woodlands, one potential outcome of this succession, rarely occur in Britain (Radley 1994). Palaeo-ecological investigations into past presence of dune woodland in the United Kingdom are limited (Provoost *et al.* 2011). Development of woodland cover may have been limited by sand dynamics during geomorphologically active phases (May & Hansom 2003). When sand dunes increase in stability, scrub can develop, some of which, such as juniper in Scotland, are rare. However, it is the diverse mix of open sand dune habitats that underpin most of the biological interest. These vary between sites and within sites due to differences in successional age, soil pH, local disturbance, management history, topography, groundwater chemistry and the dune slack hydrological regime (Everard *et al.* 2010; Stratford *et al.* 2013).

Machair is a distinctive type of coastal habitat complex, with around 11,680 ha in the north and west of Scotland. 'Machair' refers to a relatively flat and low-lying sand plain formed by dry and wet (seasonally waterlogged), short-turf grasslands above impermeable bedrock, a habitat termed 'machair grassland'. However, the 'machair system' has a wider definition that includes the beach zone, mobile and semi-fixed foredunes, dune slacks and grassland, swamps, lochs (some of them brackish), saltmarsh, and sand-blanketed adjacent slopes. Due to the sequence of habitats in the machair system, some overlap exists with other coastal habitats. It has significant geomorphological interest (May & Hanson 2003) with the main features described by Angus (2006). It is associated with calcareous sand, blown inland by strong prevailing winds from beaches and mobile dunes. With a landward sloping gradient there is commonly an inland transition to heath and mire which can include sand-affected peatland. Machair has a long history of human management over several millennia, the term owing as much to its cultural context as it does to its natural context. Current management comprises seasonal extensive winter cattle grazing, low-input low-output rotational cropping of oats and rye, and a small amount of bere barley. This traditional mixed management sustains varied dune, fallow and arable weed communities and the periodic ground disturbance and seasonal absence of stock supports important breeding bird populations. The wider machair system has a rich invertebrate fauna (Jones *et al.* 2013). Annex I habitat types are shown in Table 2.

## 2.3 Coastal shingle

Shingle (or gravel) is defined as sediment with particle sizes ranging from 2 to 200mm: too large to be moved by the wind, needing wave and storm processes to form beaches and other forms of shingle structure above the high tide mark. This process also results in 'sorting' of the shingle by size. Although globally restricted to high latitudes and in those parts of the temperate world that were affected by Pleistocene glaciation (Doody & Randall 2003), shingle beaches are widely distributed around the British coast with the majority in England (Table 1). Ratcliffe (1977) reports that an estimated 30% of the English and Welsh coasts has fringing shingle beaches. May and Hansom (2003) suggest that 1,040km of the British coastline is formed of shingle structures: when added to those underlying sand beaches, this increases to 2,900km. According to Sneddon and Randall (1993), most of this consists of simple fringing beaches within reach of storm waves, that keep the shingle mobile and restricts vegetation to relatively scarce ephemeral strandline communities. Seeds and nutrients of mostly annual species are deposited with tidal debris.

Larger shingle structures include spits, barriers or barrier islands formed by longshore drift, and cuspate forelands where a series of parallel ridges piles up against the coastline. Some shingle bars formed in early post-glacial times are now partly covered by sand dunes, reflecting depositional history and ongoing coastal change (May &

Hansom 2003). Other coarse sediment structures that support vegetation include cheniers. These are isolated sedimentary features often found on the intertidal (Neal & Pye 2002). Locations of shingle locations and some additional survey work in England and Scotland are reported in Murdock *et al.* (2010), Murdock *et al.* (2011) and Murdock *et al.* (2014).

Shingle vegetation communities depend on the extent and age of the system, amount of finer materials mixed in with the shingle, and on the hydrological regime. This influences the type of Habitats Directive Annex I habitat that may occur. Species that establish on the seaward edge can withstand exposure to salt spray and some degree of burial by sediment, or are annuals, recolonising each year (H1210 Annual vegetation of drift lines). Further from the shore, surface conditions are more stable, but still highly stressed due to the freely-drained and nutrient-poor substrate. Here, mixed plant communities equivalent to H1220 Perennial vegetation of Stony banks can develop, including grassland, lowland heath, moss and lichen communities, or even scrub. Some communities appear to be specific to shingle, and a few are only known from one or two sites. On the parallel ridges of cuspate forelands, the differing particle size and hydrology results in linear patterns of vegetation interspersed with bare shingle. Studies published in the 1990s (Sneddon & Randall 1993, 1994a, 1994b, 1994c) were ongoing when the 1989 guidelines were published. These developed a detailed classification and description of shingle vegetation, with communities that correspond to NVC types (See selection units in Annex 1 of this chapter and cross-tabulation at http://jncc.defra.gov.uk/page-2644), although with some particular characteristics that recognise these more ‘terrestrial’ vegetation types having greater special interest when occurring on shingle. For example, MG1 grassland is generally considered as a degraded grassland type of low botanical interest, but is an early phase of shingle vegetation that occurs quite naturally on key sites such as Dungeness (Ferry *et al.* 1990). It is made clear in the Lowland Grasslands SSSI Guidelines Chapter (Jefferson *et al.* 2014), that where mesotrophic grassland occurs in coastal situations, it should be assessed using the selection guidelines set out in the coastal chapter.

## 2.4 Maritime cliff and slope

Maritime cliff and slope systems occur along approximately 4000km of the British coastline, over half in Scotland (Table 1). These can broadly be classified as 'hard cliffs' or 'soft cliffs', although intermediate types occur where there are mixed strata. The term ‘Maritime Cliff and Slope’ encompasses the whole range of coastal cliff habitats in Britain and is equivalent to H1230 Vegetated sea cliffs of the Atlantic and Baltic coast.

Hard cliffs are vertical or steeply sloping, formed of weather-resistant rocks such as granite, sandstone and limestone, but also softer rocks, such as chalk, which erode to a vertical profile (but see point on chalk below with reference to ‘soft’ cliffs). Hard cliffs support specialised higher plants on ledges and in crevices. The vegetation varies according to wind and salt spray exposure, aspects of the chemistry of the underlying rock, the water content and stability of the substrate.

On hard cliffs, true maritime (i.e. halophytic) vegetation occurs with the highest exposure to salt spray from waves and winds. In Britain these are generally on the northern and south-western coasts. Ledges on such cliffs support a specialised maritime flora. In extremely exposed conditions, such as on the Isle of Lewis, saltmarsh vegetation can occur on ledges and cliff-tops (Haynes 2016). Where cliffs occur adjacent to sand dunes, windblown sand can accumulate on the cliff-slopes and tops resulting in a form of dune vegetation (climbing and perched dunes). At the lower levels in the wave splash zone on exposed hard cliffs, lichens are often the main vegetation, and may grade into rocky shore communities as described in the marine sub-chapter (Brazier *et al.* 2019).

Where the underlying geology is predominantly boulder clay or other unconsolidated material, they are classified as soft cliffs. Such cliffs are often characterised by slips or areas of slumped cliff face or slopes that gradually become vegetated. Soft cliffs form less steep slopes than on hard geology, and are therefore more easily colonised by vegetation, although this may not always be permanent due to frequent slumping and landslips driven by high groundwater pressure and marine erosion. Soft cliff vegetation is formed of the elements on the slopes or cliff faces as well as transitions on the cliff tops.

Chalk cliffs can be considered intermediate between hard and soft cliffs, with characteristics of both. This is a very restricted type of coastal cliff.

The cliff-top zone on hard and soft cliffs extends landward to at least the limit of maritime influence (i.e. the limit of salt-spray deposition), which in some exposed situations may continue for up to 500m inland, taking in entire islands or headlands. As the influence of salt spray decreases inland, the cliff top vegetation can show a zonation from open communities of drought-tolerant species (therophytes) on thin soils, towards maritime forms of grassland, heathland and para-maritime communities further inland. These are uncommon as they are often truncated by agricultural intensification. On the seaward side, the cliff habitat extends to the limit of the supralittoral zone and so includes any splash zone lichens and other species occupying this habitat. Both hard and soft cliffs may have extensive areas of bare ground or rock on vertical or gentle slopes between the cliff foot and the cliff top zone.

## 3 National and International importance

3.1 Coastal habitats are nationally and internationally important for the conservation of flora, fauna, geological and physiographical features, not least because of their natural or near-natural qualities and how they vary across Great Britain. Coasts are biologically diverse due to the climatic and geological influences, from exposed Atlantic shores and hard cliffs to the west, to the softer and lower lying coastal estuaries that typify the east coasts. Many iconic coastal sites were described in the 1977 publication ‘A Nature Conservation Review’ (Ratcliffe 1977) with information about the high level of naturalness and diversity. This built on the work by Steers (1964, 1973) which developed broad understanding of the scientific and cultural importance of coastal environments. Bainbridge *et al.* (2013) highlight the importance of ‘Naturalness’ as a criterion and that sites with limited or no direct human modification have the greatest value (Section 5.9.1 Bainbridge *et al.* 2013).

3.2 Vegetation types at the coast support considerable plant diversity; however, the conservation value of the habitats should not just be based on number of species present, but on the communities adapted to the conditions found in such dynamic environments, which can include remote islands with naturally limited diversity. Vegetation types range from pioneer communities on soft cliffs or strandlines with a limited suite of species, to more plant-rich vegetation of fixed dunes or upper saltmarsh.

3.3 Coastal habitats are recognised by national and country level conservation policy and legislation. All coastal habitats are covered by the country-level lists of ‘priority habitats' in England, Scotland and Wales[4]. These are habitats considered to be of principal importance or the highest priority for the conservation of biological diversity. The British extent of coastal habitats (Table 1) is relatively small in comparison with some terrestrial habitats such as woodlands or upland heath.

3.4 Annex I of the Habitats Directive 1992[5] lists includes a wide range of coastal and marine habitats of European importance. Bainbridge *et al.* (2013) emphasise that any habitat of international importance is a priority to protect in the SSSI series. Part 1 of the guidelines specifically names all coastal habitats, including machair, as being of international importance. Coastal habitats are highly localised internationally, but are well represented, and therefore qualify as especially important in Great Britain. Annex I habitats are natural and semi-natural habitat types of community interest whose conservation requires the designation of Special Areas of Conservation within Europe. Of these, 17 coastal habitats are found in Great Britain, several of which are 'priority' habitats (those habitat types which are considered to be particularly vulnerable and are mainly, or exclusively, found within the European Union (Article 1d) http://jncc.defra.gov.uk/page-1467). These European habitat types and relationship to NVC or other relevant classifications are based on the EU28 Interpretation Manual (Commission of the European Communities 2013). Also, under the Ramsar Convention's definition of wetland, all parts of the intertidal and near-shore marine coastal zone are included, and several coastal sites are within Ramsar sites due to their habitat and/or species interests.

3.5 Due to its position at the western fringes of Europe with a strong Atlantic influence, the British coast supports many species at the geographical extremes of their range. For example, plants such as *Spartina maritima* on saltmarshes in southern England are on the northern edge of their range which extends from southern Europe and Africa (Garbutt *et al.* 2015). *Mertensia maritima* is at the southern edge of its range in Scotland (Stewart *et al.* 1994). The coastal habitats of Britain are therefore critical to the European distribution of these and other species.

3.6 Bainbridge *et al.* (2013, Section 6.3) state: "If an area, habitat or species is identified as being of international importance, it must be of special interest in its national occurrence within Great Britain (as long as it occurs naturally). In these cases, it may be necessary not to rely on choosing only a minimum number of exemplary areas, but to select more or all sites above a critical international standard, in order to meet international conservation obligations. Where international designations are compound sites (i.e. contain several parcels of land), all of those parcels of land should be considered to be of special interest, and all of the internationally-recognised features should be reflected in the SSSI designation. This can apply to habitats which are extensive (e.g. blanket bog) or fragmented (e.g. woodland)." This means that all occurrences of habitats meeting the definition of a Habitats Directive Annex I habitat could be considered for SSSI selection. This would need to be supported by evidence that shows how the principles of site selection set out in Part 1 Section 5 are met.

## 4 Past and potential future changes in coastal habitats

4.1 The natural dynamism of coastal environments means that adjustments to morphology and extent occur constantly from natural forcing pressures such as isostatic land

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[4] Section 41 (England) of the Natural Environment and Rural Communities (NERC) Act 2006 http://www.legislation.gov.uk/ukpga/2006/16/introduction; Section 2(4) of the Nature Conservation (Scotland) Act 2004; Section 7 of the Environment (Wales) Act 2016

[5] http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm

changes or fluctuations in sediment deposited or eroded by waves, wind and storms and compounded by changes in sea level.

4.2 However there has also been direct or indirect change from human activities, mainly since 1945. The trends in coastal margin habitats have been described by the UK National Ecosystem Assessment (Jones *et al.* 2011). Interventions such as land claim or quarrying often lead to longer term changes as the system attempts to adjust to a new form of 'equilibrium'. This causes change in extent of intertidal areas, or foreshore steepening. Examples include embanking of the coastal flood plain for land claim affecting sediment processes, or stabilisation of cliffs causing beach lowering (UKMMAS 2010). Impacts of past interventions on coastal processes are ongoing and will potentially increase in the face of sea level rise (Orford & Pethick 2006). Land use changes also affect the quality and extent of coastal habitats. These include declines and intensification of grazing on some habitats, afforestation, water abstraction and agricultural improvement as well as eutrophication from air and water pollution.

4.3 There is limited detailed information at a British level on trends for the whole resource, but for some habitats historic changes have been substantial. What is less clear is how the coastal environment, with its legacy of past intervention, will adjust to climate change in the future.

4.4 Reviews of potential climate change impacts have identified several risks (Rees *et al.* 2010; Mossman *et al.* 2015). A serious issue facing coastal habitats in future may be the reduction in sediment availability which could have implications for the long-term sustainability of certain features. Accurate assessment of both sediment inputs and volumes needed to substation coastal landforms is challenging. A study covering the southern North Sea indicated that there may be insufficient sediment availability to meet current and near-future demand to prevent foreshore steepening (Orford & Pethick 2006), and increases in the rate of sea level rise will substantially alter the sediment balance. Mossman (2015) concludes that there will be a requirement to manage the coast in a more adaptive way than in the past. Both sea level rise and changes in rainfall patterns and temperature will need to be taken into account in management of protected sites (Natural England/RSPB 2014). Increased nutrients from air or water pollution, management of habitats and the requirement to deliver sustainable coastal risk management are all factors that affect coastal habitats in the protected sites network, and which need to be considered in site selection.

4.5 The coast experiences episodic change, through cliff recession, landslides, storm events and floods, and constantly undergoes a longer-term adjustment to sediment supplies and sea level rise. These facets of dynamic habitats are highlighted in Bainbridge *et al.* (2013, Section 8.7). Naturally driven change can be essential in some cases for the biological or geomorphological scientific interest of a site, with consequences for extent or quality of coastal habitats. Each case will be different but likely predicted changes and measures to address these should form part of the consideration for site selection, with site boundaries large enough to allow relevant processes to occur naturally. Changes in management of the coast to adapt to these changes will also be needed. Each site will have its own requirements: at a **minimum,** predicted change over the next 20 to 30 years should be taken account of in setting boundaries. This is in line with recommended time scales for climate change adaptation (Natural England/RSPB 2014).

# 5 Selection requirements

## 5.1 General principles for all coastal habitat types

The approach set out in the 1989 guidelines was based on selecting sites according to how the following influenced floristic variation:

- geographical location;
- geological variation;
- different vegetation types;
- completeness of succession/zonation;
- history of management; and
- maritime exposure/influence.

These are all still relevant and can be related to the key principles for selection of SSSIs set out in Bainbridge *et al.* (2013, Section 5) of: Typicalness, Fragility, Size, Diversity, Naturalness, Rarity, Ecological Coherence, Potential Value and Recorded History. However, in 1989, the level of information on the overall British resource of each main habitat was incomplete. Although there is still more to learn about these dynamic environments, improved knowledge of the distribution, type and status of coastal habitats enables a better understanding of the conservation importance of the remaining resource, the processes that sustain them and how to allow for future adaptation. The revised guidelines place more emphasis on the critical standards approach, as the principle of choosing only the best examples is appropriate only to extensive and continuous types of habitat (Bainbridge *et al.* 2013, Section 4.8).

5.1.1 Typical examples of semi-natural or near-natural plant communities (based upon NVC or similar classifications) that comprise the range of variation across each main coastal habitat within each AoS should always be considered for selection and assessed against the attributes in 5.1.2 below. Plant community descriptions and variations for sand dunes, saltmarsh and some cliffs can be found in Rodwell (2000), Dargie (2000) or for shingle in Sneddon and Randall (1994). Other NVC volumes cover some additional habitat elements, such as coastal heath in Rodwell (1991). Where there are examples of other non-coastal NVC types in a coastal situation, first take account of guidance in the relevant chapter. A second step would be to determine how they interact with the coastal habitat, and if they have distinguishing elements due to their location near the coast. If the latter, then these should be considered as an element of the coastal system and addressed primarily using the relevant part of this Coastlands chapter.

5.1.2 The successional and transitional nature of the main coastal habitats, and the limited extent of some elements of these habitats, requires an approach that makes greater use of the critical standards principle (all habitat type sites above a size threshold), as set out in Bainbridge et al. (2013, Section 4.8). Habitat selection units and the relevant NVC communities or equivalents (Rodwell 1991a and b, 1992, 1995, 2000, Sneddon and Randall 1993 and at http://jncc.defra.gov.uk/page-2644) are found in Annex 1 of this chapter. In practice, although selection of an SSSI could be made on the quality of one of these zones alone, combinations of plant communities will normally be assessed. Sites with one or more of the following attributes should be considered for selection:

i. the widest range and the best examples (largest and most complete systems) of the main NVC communities in the AoS and of other coastal vegetation types not described in the NVC;
ii. particularly well-defined or extensive zonations, including pioneer and mature communities and intermediate transitions or ecotones, including those that are

typically species-poor or dominated by non-vascular plants or demonstrating vegetation types strongly influenced by maritime exposure;

iii. transitions to other, terrestrial, freshwater or marine habitat types;

iv. a large area or lateral extent (for more linear habitats) relative to the overall resource (in continuous or discrete units depending on the degree of natural or man-made interruptions); and

v. important physiographic features with active processes functionally critical for coastal habitats.

The vulnerability of coastal systems to anthropogenic impacts means that even some of the smaller sites, particularly those with a limited national extent, can still be considered for selection especially where they are poorly represented on other sites within the AoS or improve geographical representation. Smaller sites can be selected for one or more reasons of:

- uncommon NVC types;
- species-richness;
- supporting rare species;
- good representations of a suite of NVC communities or Annex I habitat types;
- representing good examples of transitions, succession, ephemeral vegetation or ecotones (which may not have a good fit to described NVC types); and
- sites providing connectivity or ecological coherence that enable the coastal ecosystem and surrounding sites to adapt and evolve.

5.2 Coastal systems may also occur in a mosaic with, or form transitions to, other high-value habitats. Such mosaics and transitions in themselves may also be important in supporting species that rely on the ecotones and juxtapositions between habitats, including between different coastal habitat types. Ecotones[6] are not classified by the NVC, although zonation and succession are part of the community descriptions. Ecotones should be considered for selection, especially any unusual types and in accordance with principles set out in Bainbridge *et al.* (2013, Section 7.3). The diversity of habitat types, species composition and any other special features would need to be assessed as required. The value of ecotones and mosaics can be equally important as the adjoining communities. Some sites demonstrate a greater value from the combination of all the biological components rather than consideration of individual elements. In such cases it is recommended to review the evidence using specialist advice.

5.3 Management history and current management are important. Some of the variation in species composition and sward structure can be attributed to grazing, particularly on saltmarshes and sand dunes. Grazing can be by either domestic livestock or wild herbivores, including wildfowl. The 1989 guidelines distinguished between grazed and ungrazed saltmarshes, based on work by Adam (1978), who recognised that saltmarsh in south-east England ungrazed by domestic livestock tended to support species-rich upper saltmarshes, but also that in the west, light grazing can increase species diversity by reducing competitive plants. The loss of upper saltmarsh zones as a result of embankment means that these plant communities are important where these persist, even if incomplete. Sea walls can act as refugia for some species of these transitional zones, particularly annuals (Gardiner *et al.* 2015).

[6] Ecotones can be between habitats (dune to saltmarsh); within habitats (mobile dune to semi-fixed dune); between systems (intertidal to terrestrial); or as a result of changes in underlying sediment (boulder clay to hard geology on cliffs) affecting competitive ability of plant species. They may also be maintained by small scale process such as flooding, saline incursion or minor erosion. See Bainbridge *et al.* 2013, Section 9.1 for more details.

5.4 Coastal habitats are important for a range of species groups, in particular, bryophytes, lichens, fungi, invertebrates, birds, fish, reptiles and amphibians, as well as for scarce and declining vascular plants. Thus, reference should also be made to relevant species chapters of the SSSI Selection Guidelines. A small site with coastal habitats supporting these species could still be considered for selection on species grounds.

5.5 Presence of non-native or invasive species, such as sea buckthorn, on sand dunes should not preclude sites from being selected, but supporting information should indicate management needs to improve condition. Evidence to support selection should present current knowledge of the extent and type of invasive species present and the degree of threat and management needed to limit their impact on the special features. See section 6.3.1 for more detailed information on *Spartina anglica.*

5.6 Coastal habitats within systems supporting important physiographical features such as sedimentary processes, accretion/erosion sequences should also be selected. The selection of SSSIs for coastal geology and geomorphology is guided by the Geological Conservation Review (GCR; see May & Hansom 2003; JNCC 1977). Other sites not listed by the GCR can also demonstrate good conservation of geomorphological structure and function. In particular, active processes are essential to enable new habitats to develop as a result of natural change or creation measures. It is the interaction between these processes and the biological factors in habitat development which is important to include in the site series.

5.7 The type and nature of the underlying geology and soils influence the development of vegetation. Locations demonstrating differences between, for example, acidic and calcareous sediment should be selected, and even small sites supporting the less common examples should be considered for selection.

5.8 Hydrology influences the extent and quality of coastal habitats, from small seepages on soft cliffs to underlying water tables in dune systems, as well as providing variation in saltmarshes where freshwater flows emerge onto the intertidal. Water availability, quality and chemistry need to be maintained to conserve these elements of the system, and good examples should be selected. The importance of considering the whole hydrological system means that the boundary should incorporate the wider catchment where practicable. Sites important for sand dune slacks, which rely on a discrete hydrological system recharged from rainfall (Davy *et al.* 2010), may need the whole dune surface to be included in the boundary to ensure protection and restoration of the water table.

5.9 Although often perceived as extensive, coastal habitats covered by this chapter are relatively scarce compared to some terrestrial habitats, for example blanket bog or lowland heathland. Within coastal environments, individual plant communities can be rarer still. For example, within sand dunes, the ‘Fixed dune’ plant NVC community SD8 *Festuca rubra-Galium verum* fixed dune grassland covers less than 4000ha in England ((based on Radley (1994), with 14,900ha in Scotland (Dargie 2000)[7] and 1138ha in Wales (Dargie 1995)). Sites supporting this community will inevitably have other dune vegetation which should all be selected. There is no pre-determined requirement for how much of the national resource of either broad habitat or NVC community level should be selected and the international importance of British coastal habitats means that some types, such as shingle systems, should be well-represented in the site series.

[7] updated in 2017 by Habitat Map of Scotland to 10271ha (Table 2).

5.10 The dynamics of the coastal environment mean some habitat types are ephemeral, with occurrence influenced by seasonal factors or changes to coastal morphology, erosion and seepages. Examples of these include flush and scrub communities of cliffs, often with a high proportion of bare ground, or the seasonal strandline annual communities of dune or shingle. The presence of these habitats can indicate naturalness and is therefore a factor in site selection.

5.11 Coastal habitats include some of the least modified in Great Britain, and as such these should be afforded the highest value (Bainbridge *et al.* 2013, Section 3.7). Smaller sites should be considered for selection where there is a high degree of naturalness within them. As these habitats are scarce, vulnerable and difficult to restore, a greater proportion should be covered by the SSSI series. Climate change is putting more pressure on existing coastal habitats. Current sea level rise projections will increase these pressures. There is therefore a need to notify sites that improve the capacity of the SSSI series to adapt in future, which was not a consideration in the original guidelines (Bainbridge *et al.* 2013, Section 2.11). This also means that where restoration or creation projects for coastal habitats are successful, these sites should also be considered for addition to the network, usually by expansion of existing sites.

**5.12 Areas of Search**

Areas of Search (AoS) are particularly important when selecting the best examples of sites within an area. When using AoS, account should be taken of how these relate to sediment processes which influence coastal habitats. Some AoS will have a large proportion of the national coastal habitat resource, so consideration also needs to be given to the context of individual sites or suites of sites as part of their overall GB or country resource.

**5.13 Selection requirements by habitat**

5.13.1 Saltmarsh

Adam (1978) differentiated three main types of saltmarsh on the basis of location and grazing which were used in the 1989 selection guidelines to determine size thresholds. The Saltmarsh survey of Great Britain (Burd 1989) used a similar geographical basis for presenting results, both pre-dating completion of the full NVC. There is now a body of additional information about variation within saltmarsh vegetation, the importance of structure and morphology, the role of grazing and sediment processes, including the impacts of past land-claim (Boorman 2003). Oceanity and latitude will also influence vegetation; hence grouping into such large areas may not be so appropriate and sites should be selected using the AoS set out in Bainbridge *et al.* 2013 (but subject to considerations explained in section 1.14 above). All sites above 50ha should be considered for selection. Size thresholds do not relate to continuous stands of the habitats but the overall system within an estuary. Estuarine saltmarshes are usually formed of several discrete blocks, connected through coastal processes, and elements of the habitat can extend above mean high water springs (MHWS). In site selection, the full extent of saltmarsh and any associated intertidal mudflats below it should be selected (according to the lowest tidal limit used in each country), and extend from the outer estuary to the upper reaches with more freshwater influence. Excluding areas could affect the processes essential to sustain the habitat as a whole.

Selection of sites should be based on size, diversity and functionality as well as rarity. In the Saltmarsh Survey of Great Britain, Burd (1989) reported on surveys of 557 saltmarsh sites ranging in size from 0.5 ha to 3385ha. These were made up of several different plant communities. Small sites (10-15ha) displaying a good range of vegetation development in defined AoS with limited saltmarsh should be considered for selection. All examples of rare or scarce communities should be selected within each AoS. These include *Spartina maritima* (SM4), *Spartina alterniflora* (SM5) and uncommon transitional communities. Grazing history is an important factor to consider in site management; in general grazing should not be introduced onto ungrazed marshes.

For *Spartina anglica*, the 1989 guidelines indicate that '*there are no reasons for selecting this habitat alone on botanical grounds'*. This is still the case, but there is now more knowledge from research on key sites. Since the original guidelines were published, the taxonomic status of *S. anglica* has been reviewed. It is now considered as 'endemic as a native to Britain' (Preston *et al.* 2002) but recognised that it is not possible to map planted or naturally colonised populations differently in the Atlas. A further factor to consider in selection is the potential value of *Spartina anglica*-dominated areas as a precursor to other saltmarsh.

*Spartina anglica* can occur in as a dominant species in certain zones of saltmarshes. Its distribution is influenced by former planting to help accrete sediment prior to land claim (Doody 2008a; Lacambra 2004). In other locations it colonised without intervention, and although evidence is limited, its distribution may still be changing (Lush *et al.* 2016). The combination of die-back in some southern locations where it was once dominant, and erosion of other stands as sea level rises, are potential factors driving ongoing change. In contrast, where there is adequate sediment, large stands of *S. anglica* have succeeded into mixed saltmarsh (Lacambra 2004). Selection of sites where this species is present will need to take into account the dynamics of the individual site or estuary system and predicted changes over time. *S. anglica* presence does not preclude selection if other elements of the saltmarsh system are present, and it should be considered as having potential value through succession into other saltmarsh communities. In general, it can be included where it forms an element of the saltmarsh habitat, especially as pioneer saltmarsh often in proximity with other pioneer species and areas currently dominated by *S. anglica* should generally be included within site boundaries.

Consideration needs to be given to the selection of sites where intertidal habitats are developing as a consequence of managed realignment, tidal exchange or natural breach restoring tidal inundation to the original coastal flood plain. Such processes in themselves are of scientific interest, as they initiate vegetation development mainly through natural dispersal towards habitats with potential value (as set out in Bainbridge *et al.* 2013, Section 5.12). Rates of habitat development and the ultimate vegetation composition will vary, and there is a recognised need for more research (Spencer & Harvey 2012). Recognisable saltmarsh communities can develop within about 15 years, generally without the need for other intervention (Garbutt & Wolters 2008) although full restoration will take much longer. Bainbridge *et al.* (2013) highlight that adaptation to climate change means that greater flexibility might be needed when considering the biological interest of restored or created habitats. Each site will require evaluation of available data. Consideration should be given to selecting sites, or amending existing boundaries that help to provide ecological coherence where:

- saltmarsh vegetation is developing naturally relative to surface elevation and active processes that support saltmarsh (recognising that vegetation types may not stay the same as the site evolves);
- the location is functionally linked to an estuary system or the open coast;
- tidal inundation has re-started as a result of a natural event;

- there are ecotones to other habitats; and
- restored habitat enables the wider coastal system to support qualifying populations of species.

5.13.2 Sand dunes and machair

As with saltmarshes, sand dunes and machair should be considered as whole systems. May and Hansom (2003) indicate that there are 295 separate dune sites in Britain, and also list nine separate machair GCR sites.

All elements of the dune succession should be represented from the functional beach plain, strandline vegetation, the whole area of vegetated and unvegetated sand deposits and transitions to landward where present. In machair these transitions include a range of other habitats[8]. The majority of the British sand dune and machair communities are included within the definitions of the Habitats Directive Annex I habitats, listed in Table 2.

**Table 2**. Indicative area of Sand dune and Machair Annex I habitats in GB (NB Country level studies should be referred to for more recent estimates). For England and Wales based on data compiled in 2008 by Doody (2008b), using data from 2000 or earlier (Dargie 2000; Radley 1994). Scotland figures are reclassified data from Habitat Map of Scotland (based on Strachan 2017).

| **Annex I dune habitat (*denotes priority habitat)** | **Area Scotland (ha)** | **Area England (ha)** | **Area Wales (ha)** |
|---|---|---|---|
| H2110 Embryonic shifting dunes | 251 | 100 | 100 |
| H2120 Shifting dunes along the shoreline with *Ammophila arenaria* (‘white dunes’) | 1325 | 780 | 480 |
| H2130 * Fixed dunes with herbaceous vegetation (`grey dunes`) | 10271 | 3900 | 2700 |
| H2140 decalcified fixed dunes with *Empetrum nigrum* | 486 | Not present | Not present |
| H2150 * Atlantic decalcified fixed dunes (*Calluno-Ulicetea*) | 1173 | 190 | 40 |
| H2160 Dunes with *Hippophaë rhamnoides* | 80 (introduced) | 235 (some introduced) | introduced |
| H2170 Dunes with *Salix repens* ssp. *argentea (Salicion arenariae*) | 170 | 230 | 230 |
| H2190 Humid dune slacks | 1338 | 200 | 390 |
| H21A0 Machairs | 11680 | Not present | Not present |
| H2250 Coastal dunes with *Juniperus* species | 20 | Not present | Not present |

Each of the Annex I habitats listed in Table 2 corresponds with one or more NVC types, but in dune or machair systems environmental gradients result in a large amount of variation, which means classifications only work well with the more typical stands. Surveys have described several new intermediate communities and sub-communities not described in the current NVC types (Dargie 2000 for example). The limited extent combined with the international importance of these habitats means that all examples can be considered for selection. For sand dune communities, the NVC has been revised since 1989 and the current descriptions published in Rodwell (2000). The list of selection units in Annex 1 shows the

[8] https://www.nature.scot/landscapes-habitats-and-ecosystems/habitat-types/coast-and-seas/coastal-habitats/machair.

communities included in Volume 5 (Rodwell 2000) which should be used as the basis for selection, but taking account of new descriptions of dune communities where relevant and the increased understanding of machair systems. Other heathland and wetland communities that can also occur on dunes are included in Annex 1, with the relevant NVC publication.

Where there are good examples of one or more phases of dune or machair vegetation succession, the whole system should be selected. This ensures that factors such as dune hydrology and nutrient status can be managed within a site.

Ecological variation reflects the chemical properties of the substrate. Acidic systems are less common. All examples of acidic dune heath on coastal sands should be considered for selection due to their very limited extent within Britain. These are defined in the NVC by the heathland community types H1 *Calluna vulgaris-Festuca ovina* heath, H10 *Calluna vulgaris - Erica cinerea* heath, *Festuca ovina - Anthoxanthum odoratum* sub-community, H11 *Calluna vulgaris - Carex arenaria* dune heath (Rodwell 1991) where these occur on sand dunes. The origin of coastal dune heath is likely to have been different to lowland heath, but this has not been well-studied (Wilson *et al.* 2001). The balance of influence between anthropogenic clearance of any woody species on dunes and leaching and acidification of stable dune soils leading to colonisation by heathland species is unclear. Dune heath can be found grading into lowland heath, but all dune sites would qualify for selection as a coastal habitat in addition to the adjacent terrestrial heathland, referring to the Lowland Heathland chapter (Alonso *et al.* 2018). On older dunes or those with lime-deficient sand feeding the system, acidic grasslands are found. These may be rich in lower plants. Geographical variation within dune heath is limited, though *Empetrum nigrum*, which has a generally northern and western distribution, may be an important element in wetter heaths. *Juniperus communis* also occurs at a small number of sites and forms an important variant of northern dune vegetation. *Corynephorus canescens* is very restricted and is mainly found on a few east coast sites in southern England as well as some inland dunes and heath (Jefferson *et al.* 2014, Alonso *et al.* 2018). Lichen-rich communities are also characteristic of ungrazed or lightly grazed dune heath.

Dune slacks are also an uncommon element of sand dune systems, representing less than 3.5% of the British dune resource. Slack size varies from site to site: some sites can have extensive areas but distribution within sites is limited by dune topography. Slacks form in damp or wet hollows between dune ridges, where groundwater reaches or approaches the sand surface (Davy *et al.* 2006, 2010), typically with a seasonally fluctuating water table, and may be calcareous or acidic. Two types can be distinguished on the basis of their geomorphological history: primary and secondary slacks. Primary slacks originate from sandy beaches, which have been partially or fully cut off from the influence of the sea by new foredunes, particularly in prograding systems. Secondary slacks form from blowouts where dune ridges erode down to the water table. All slacks have several stages reflecting hydrological processes and management and support a high diversity of vascular and non-vascular plants as well as other species. There is increasing evidence from projects in Wales and across Europe that restoration of slacks is possible, and because of the rarity of this element of dune systems, slack areas currently in poor condition but with potential value (as outlined in section 5.12.1 of Bainbridge *et al.* 2013) should also be considered for selection along with all good examples.

The 1989 guidelines-based qualification for selection firstly on size, requiring all dune sites over 200ha to be selected and, for machair within the western and northern Highlands and Islands, any discrete and functional machair system exceeding 400ha. These areas are still relevant but, due to variation in the different types of dune formation, are most appropriate only when considering the more extensive hindshore systems. Dunes on spits, nesses and barrier islands are generally smaller systems and selection should be based on the quality of the habitat rather than extent alone. The associated beach plain must be considered as part of the dune system and included within the boundary. Any sites with a near-complete succession from beach plain, accreting foredunes to stable dunes with slacks, grassland or heath are important and should be considered for selection even if less than 200ha.

Smaller sites which may only be able to support a limited succession due to their morphology should also be selected on the basis of:

- variations in the substrate from acidic to calcareous, best examples of plant sub-communities (Annex 1 of this chapter) determined by extent, floristic richness and indicator species;
- the best combinations of dunes with other coastal habitats especially saltmarsh or shingle;
- the best example of any machair (of any size and including machair arable land) less than 400ha showing functional or vegetation features not included in the largest sites;
- the best examples of the range of physiographic features representing the different processes of dune formation; and
- different structural types of dune systems (particularly spits and linear formations) providing elements of coastal morphology of functional importance to other habitats such as saltmarsh within estuary systems.

5.13.3 Coastal shingle beaches and structures

Coastal shingle formations able to support either annual or perennial vegetation are scarce in Britain, with a total area less than 6,000ha (Table 1). Sites on fringing beaches may only support ephemeral or pioneer vegetation (NVC types SD1, SD2 or SD3). Where these occur regularly, or have been recorded in the past, sites should be selected that provide adequate opportunities for vegetation to colonise along the coast within the range of the main species that form the basis of these plant communities (for example *Mertensia maritima, Lathyrus japonicus and Crambe maritima*).

Sites with vegetation on older beach ridges beyond the reach of waves are generally on larger shingle structures extending inland from a shingle beach. Studies in the 1990s and more recent inventories (Sneddon & Randall 1993, 1994a, 1994b, 1994c; Murdock *et al.* 2010, 2011, 2014) provide an overview of the whole British resource and the wide range of variation in the vegetation. The Sneddon and Randall classification included 124 communities, corresponding with a range of NVC communities. This combined classification should be used in site selection, ensuring that it is clear that the vegetation is based on a shingle substrate at or close to the coast, to avoid confusion with other habitat guidelines. The 1989 guidelines recommended selecting vegetated shingle structures larger than 25ha, and including naturally unvegetated areas and areas with potential for restoration, which still applies, but all examples of any size should be considered, particularly where they support examples of less common vegetation types. Combinations of vegetated shingle with other sedimentary coastal habitat should also be represented.

5.13.4 Maritime cliffs and slopes

All cliff systems with good structure and function with a range of vegetation types should be considered for selection. All cliff vegetation is typically a mosaic of bare surfaces and near-natural vegetation, with transitions to landward. Maritime grassland, maritime heath and other coastal slope or cliff-top vegetation on steep or gentle cliff slopes with evidence of maritime influence (for example the presence of halophytic plant species, maritime exposure or land instability) should be considered for selection. Other semi-natural sub-maritime or para-maritime vegetation should also be considered under the coastal selection guidelines to ensure continuity of the habitat over time (see section 6.5).

The twelve maritime cliff (MC) vegetation communities described within Volume 5 of the NVC (Rodwell, 2000) cover quite a wide range of hard cliff vegetation, in conjunction with other vegetation types such as heathland (Rodwell 1991) where these are more or less restricted to coastal cliffs.

Vegetation of soft cliffs was less well-studied prior to the publication of the 1989 guidelines and Rodwell (2000). The presence of a range of soft cliff plant communities has been better documented in more recent coastal surveys. Both hard and soft cliffs/cliff slopes are included in the Annex I habitat 'Vegetated sea cliffs of the Atlantic and Baltic Coast' (Commission of the European Communities 2013).

A review of the NVC (Rodwell *et al.* 2000) highlighted a *Tussilago farfara-Festuca rubra* community within the 'open ground' section but which is relevant to soft cliffs/cliff slopes (see Annex 1). Similar communities have also been described by several other studies, for example on the Isle of Wight (Cox 2010).

Soft cliffs and cliff slopes unaffected by cliff stabilisation measures are a relatively scarce habitat, with an estimated length of 256km in England, two-thirds of the British extent. Wales supports approximately 100km of soft cliffs (Howe 2002). These environments show different rates of erosion depending on local geology, whilst also providing a source of sediment for other parts of the coastal environment such as beaches and saltmarshes.

The site series should include major geological and structural differences along a cliff coast and the associated range of different habitats and the unique ledge vegetation associated with major seabird colonies (bird interests will be selected according to Drewitt *et al.* (2015).

The highest cliffs will often be the most important, but lower cliffs above 5m high should be considered for selection where they support permanent or ephemeral vegetation. Maritime forms of cliff-top heath or other hinterland habitat should also be selected under these coastal guidelines, with cross reference to the relevant chapter where habitats extend beyond the para-maritime zone. Selection of sites within each AoS should ensure adequate representation of the main cliff NVC communities and sub-communities characteristic of the geographical zones. The best examples of vegetation types listed as selection units (Annex 1) should be included for each relevant AoS, especially where these are on unmodified continuous stretches of cliff. Even within a single geological formation, extended or additional sections should be selected to include important sub-maritime/para-maritime habitats such as cliff woodland and scrub and cliff-top heathland of high floristic interest. This will be particularly important where unstable cliffs support ephemeral communities, flushes (often of significance for invertebrates) and other non-maritime vegetation on landslides, for example those associated with clay or chalk deposits. There are floristic features which are important within each of the main geological formations, and the distinctive northern and southern floristic elements should also be represented in the site series within the three following groupings:

i. Vegetation on rock crevices and ledges
Geographical relationships are best seen in this open vegetation: in the south, this is characterised by the presence of MC1 with *Crithmum maritimum* or *Inula crithmoides* in the rock crevices. MC2 is the northern equivalent of MC1 and has *Ligusticum scoticum* replacing these two species. Rock-ledge vegetation has *Brassica oleracea* in communities of MC4 as a southern type. *Rhodiola rosea* (MC3) replaces *Brassica oleracea* as the northern equivalent of MC4.

ii. Maritime cliff and cliff-top vegetation
A variety of communities and sub-communities (MC5-10) is represented within this grouping. Communities MC6 and MC7 represent a nutrient-enriched vegetation occurring on seabird cliffs.

iii. Sub-maritime and para-maritime vegetation including cliff slopes
On the south and east coasts some cliffs, or parts of them, are not fully exposed to maritime conditions because of their relatively sheltered position. In these circumstances maritime cliff communities described by the NVC may only be limited to a narrow fringe at the base of the cliff. Depending on the stability of the cliff, a variety of ephemeral, flush and scrub communities can develop on the slopes which may be important in their own right and are set out in Hill *et al.* (2001). Along with elements of MC12 (the least maritime of the NVC cliff communities, *Festuca rubra–Hyacinthoides non-scripta*), these represent one extreme of the maritime cliff and slope habitat which should, if present, be represented within the site series. Several heathland communities are also found on cliffs. Rodwell (1991) describes cliff occurrences of H4 *Ulex galli–Agrostis curtsii* heath, H5 *Erica vagans–Schoenus nigricans*, H6 *Erica vagans–Ulex europaeus* heath, H7 *Calluna vulgaris–Scilla verna* heath and H8d *Calluna vulgaris–Ulex gallii* heath which span the range from maritime to para-maritime vegetation and will need to be considered in conjunction with the Lowland Heathland chapter (Alonso *et al.* 2018) where the heathland vegetation extends inland beyond maritime influence. Where the heathland vegetation is restricted to cliffs the Coastal chapter should be used to guide selection.

## 6 Boundary definition

6.1 The lower limit of sites supporting saltmarsh should be taken as the lowest recognised tidal limit (which differs between UK countries). Other coastal habitats, as covered in this chapter, are considered to extend from Mean High Water mark as far inland as the limit of salt spray (up to 500m inland on exposed coasts) or the inland extent of the underlying sediment previously deposited by coastal processes, covering all maritime, sub-maritime and para-maritime systems, which can extend in some situations up to several kilometres inland, such as the shingle at Dungeness. Sand dune systems can extend some distance inland, especially the larger hindshore systems. Deposits of sediment such as blown sand or shingle ridges influence the vegetation type, drainage patterns and local microclimate. For machair, the extent of blown sand underlying both cultivated and natural forms of vegetation would guide the position of the inland boundary which for some machair systems can be up to 2km from the sea.

6.2 Coastal habitats are generally present as a mosaic of habitats. There is a morphological distinction between soft, low-lying sedimentary coasts and cliffed coasts. Each of these can be sub-divided into component elements but, in reality, there is a complex relationship through sediment transfer by wind, waves or currents such as that between soft cliff erosion and intertidal areas (HR Wallingford 2002). The intrinsic scientific importance of any coast is taken to include the range of semi-natural habitats and their functional interdependence through coastal processes, and this factor will influence the position of site boundaries.

6.3 Site boundaries should, wherever possible, include the full extent of the special features of the site, whole management units and the extent required to maintain functional processes, as set out in Bainbridge *et al.* (2013, Section 8.2). Consideration must be given to the area required to sustain hydrological processes, which might require the inclusion of the catchment or surface area to enable recharge of groundwater.

6.4 Saltmarshes in particular may be dependent on the presence of other features: a shingle structure may provide shelter for saltmarsh to form, and the saltmarsh would be vulnerable if the shingle area is not included in the protected boundary. Sand-dunes may similarly perform the same function. In such cases, if the saltmarsh meets the selection requirements, the supporting shingle/dune systems should also be incorporated within the site as part of the notified features. Saltmarsh also has a functional relationship with adjacent intertidal flats, so seaward boundaries usually extend to the legal limit of planning legislation, which may vary between countries (Bainbridge *et al.* 2013, Section 8.10). Further clarity is set out in the Marine and Coastal Access Act 2009 (England and Wales). Where there are adjacent marine interests, there is now clear guidance on how and when this is appropriate for England and Wales (Defra 2011) and guidance in the marine sub-chapter (Brazier *et al.* 2019).

6.5 Identifying boundaries for coastal sites with evidence of landward recession (mainly cliff sites) should follow the guiding principle set out in Bainbridge *et al.* (2013, Section 8.2): *There must be good evidence that this part of the site could support the special features for which other parts of the site are notified.* This can also take account of any underlying geological interest.

When setting boundaries, consideration needs to be given firstly to ensuring the current extent of maritime influence is taken account of, and secondly any likely future change in the position of the interest feature. Maritime influence does however vary around the country, being greater on exposed western coasts than more sheltered eastern coasts. Para-maritime communities often grade landwards into strictly terrestrial habitats, such as lowland heath (Alonso *et al.* 2018). Such gradations of habitat from coast to terrestrial are not common, and are of conservation value where they occur, so should be included in boundaries of coastal sites.

Although each case would need to be considered on its individual merits, use of expert geomorphological assessment[9] may provide a means to determine an effective boundary as part of the notification process, in conjunction with information about the ecological potential of the wider area:

- undertaking a geomorphological assessment of the degree of coastal change likely to influence the proposed site over the next 50 years;
- using this assessment to identify a line that has a high (c.95%) probability of including all likely coastal change over the next 50 years; and

[9] In England, a similar approach has been taken on several sites re-notified since 1999: Seaford to Beachy Head (1999), Porlock Ridge and Saltmarsh (2002), Compton Chine to Steephill Cove (2003), Humber Estuary (2004) and Pakefield to Easton Bavents (2005) and Dungeness, Romney Marsh and Rye Bay (2006).

- identifying a suitable SSSI boundary (one that is identifiable and unambiguous) based around this line for the notification process.

The series needs to be as resilient as possible to future climate change impacts, and individual sites need to be large enough to secure most of the processes that underpin the habitats. This is an important aspect of viability, and will mean that in some cases, small areas with limited interest, or habitats in poor condition, are included in the boundary to maintain ecological coherence. Even these limited areas can provide important function for species, such as driftline saltmarsh acting as high tide roosts for waterbirds.

## 7 Site survey requirements and wider context

7.1 Surveys are required to enable evaluation of sites against the guidelines. Good quality information on the range, quality and distribution of the habitat types present within a site is essential.

7.2 General background information about coastal habitats can be found in the JNCC Coastal Directories series published between 1995 and 1998, now available on-line at http://jncc.defra.gov.uk/default.aspx?page=2157 (accessed June 2018).

Inventories of broad habitats, including those covered by this chapter can be found on the MAGIC map site at http://www.natureonthemap.naturalengland.org.uk/MagicMap.aspx (accessed June 2018). These are not likely to provide details of individual NVC or vegetation types.

7.3 The above sources are useful context, but for notification purposes a site-specific study will be needed. Survey requirements will be similar to those set out in the Lowland Grassland Guidelines (Jefferson *et al.* 2014). Habitat surveys should enable the range of plant communities and sub-communities present to be classified and mapped using the NVC types described in Volume 5, or equivalent classification e.g. for shingle. Due to the wide variation in coastal vegetation, all NVC volumes may be relevant, as individual community or sub-community descriptions can indicate coastal variants.

7.4 Particular attention should be given to coastal habitat dynamics, successional phases, zonation and coastal variants of NVC types. A site should be surveyed and mapped using the National Vegetation Classification (Rodwell 2006), or similar coastal classification such as Sneddon and Randall (1994a) where this is appropriate to the habitat. For an explanation of the application of the NVC, refer to the NVC Users Handbook (Rodwell 2006).

To help understand any issues of future dynamic or managed change (Bainbridge *et al.* 2013, Section 8.7), the survey should take account of the mosaic of coastal and other habitats on the site, integrated with an explanation of the geomorphology at that site to help inform the location of the boundary. Information on any flood or erosion risk management or structures, their maintenance and condition would help to identify future management issues or where boundary revisions may be needed when changes occur. It is essential that evidence is gathered on how the habitats interact and the potential changes that may result from vegetation succession, coastal processes, flooding or erosion.

An effective survey will:

- demonstrate consistency of approach using a recognised standard survey methodology;

- accurately determine the vegetation types present and their species composition and spatial configuration, including area;
- enable sites to be clearly evaluated against the SSSI guidelines;
- map the location of qualifying features to inform future monitoring and changes; and
- identify any areas within the proposed boundary that would not meet SSSI selection guidelines for coastal habitats (taking account of Bainbridge *et al.* 2013, Section 8.2).

Data will also inform any management requirements, or issues that need to be addressed where the condition of the habitat is less than favourable. The use of the Common Standards Monitoring guidance for coastal habitats (JNCC 2004) can inform the assessment of condition, but this is not an adequate site survey method to collect detailed spatial data for site selection purposes.

When commissioning surveys to support site selection, it is recommended that the specifications require surveyors to have:

- knowledge of the main coastal habitats and selection requirements;
- appreciation of coastal morphology and processes that influence habitats;
- understanding of the typical patterns of succession, to enable recognition of mosaics and transitions and present a clear explanation of these in reports;
- appreciation of successional change and combinations of different communities common between key zones;
- understanding of naturally bare/open ground on coastal habitats, related to influences of sedimentary or erosional environments resulting in patterning of vegetation and ephemeral vegetation;
- plant identification skills, including key non-vascular plants;
- technical ability to capture and present data, for example use of GPS in the field, aerial photography, remote sensing, high-resolution imagery, and use of Geographic Information Systems;
- understanding of potential transitions to marine, terrestrial or freshwater habitats;
- understanding of habitat correspondences between classifications; and
- experience of safe working in coastal and intertidal environments and using appropriate Health and Safety requirements to manage risk.

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# Annex 1
# Table of Coastal vegetation selection units with tabs for shingle classification and machair communities.

Currently a separate Excel file.