Coastal vegetated shingle near Hurst Castle, Hampshire.

31. Coastal vegetated shingle*

Climate Change Sensitivity: **High**

***** Note: this term covers all shingle features at the coast. Most will have some ephemeral seasonal vegetation. Larger systems will have more permanent perennial vegetation, often with a typical pattern of vegetation growth and including naturally bare shingle.

Introduction

The Natural Environment chapter of the **UK Climate Change Risk Assessment Evidence Report** (Brown, *et al* 2016) highlights that all coastal ecosystems are at high risk from climate change, with increased vulnerability in many locations due to the presence of flood defence and erosion protection structures, which prevent landwards rollback of the intertidal zone as a natural response to sea-level rise. In addition, natural adaptive capacity is limited by reduced sediment supply due to hard coastal defences. Dynamic coastal systems have the potential to be self-regulating in the face of rising sea levels. This can only occur if there is both an adequate supply of sediment, and there is landward space for migration and adjustment of the different components relative to the tidal and wave energy frame.

Studies have established that there is a relationship between the rate of shingle (gravel) barrier retreat by roll-over and the rate of sea level rise. A higher rate of sea level rise will be associated with faster landward movement. Storm events will affect shingle coastlines, leading to a changed form and location through wave transport of sediment, including 'over-washing' and breaching. The type and scale of change will vary between 'drift-aligned' (waves entering at an angle to the coast) or 'swash-aligned' (waves are perpendicular to the coast) shingle ridges. Most shingle systems in England now have limited amounts of new sediment.

Even without natural inputs of new sediment, some shingle systems have the potential to adapt to some impacts of climate change through adjustment of their form and moving landward, often in a series of steps driven by storm events of different intensity. However, past and present interventions affect morphology or constrain sediment processes. Any built development on their landward side will restrict capacity for adaptation. Coastal engineering to 'fix' shingle coastlines will not prevent major changes and may even exacerbate breakdown. Such coastlines are therefore likely to be more susceptible to climate change where space and sediment are limited.

Key issues affecting shingle coastlines are reduced availability of sediment resulting from the construction of coastal defences that limit longshore drift, and artificial management that reduces the capacity to adjust form, position and volume as sea levels rise. With just 4,276ha of this habitat type in England (Murdock *et al* 2010) it is important that existing locations are managed effectively at all locations in ways that take account of coastal processes. Analysis of recent change in England for key sites between 1990 and 2008 suggested a slight loss in overall area (~10% loss), with five sites showing net loss and four sites net gain (Murdock *et al* 2010).

Another factor to consider is the gradual wearing of individual shingle pebbles (Dornbush *et al* 2002). Rates of abrasion are influenced more by mean wave height than by mineralogy. Beach volume could therefore be reduced faster with higher wave energy. Inland of the active beaches, the impacts of climate change on shingle habitats will include increased drought, affecting both dry and wet habitats. Hotter summers may allow the establishment of invasive species, such as red valerian or other garden escapes.

A study of visitor preferences using a shingle location (Coombes and Jones 2010) concluded that climate change may influence future levels of recreational impact on coastal habitats via modifications in numbers and types of visitors. Overall, there is predicted to be an increase in visitor numbers to these localities, with greater participation in activities which are promoted by warm and dry weather conditions, such as sunbathing and paddling. Demands for such usage will need to be planned for, alongside changes in shingle morphology and potential breaches and overwashing events.

Jones *et al* (2013) point out that the scarce nature of this habitat leads to low rates of recolonisation after disturbance. Changes in patterns of precipitation or temperature will affect vegetation composition. Water retention is poor and evapo-transpiration is likely to increase year round, but particularly in autumn and summer, exacerbating the impact of summer droughts. Larger shingle structures supporting freshwater aquifers, such as Dungeness, may become vulnerable to saline water intrusion.

Habitat Description

Shingle (or gravel) beaches occur in high wave energy environments, with deposition of sediment driven by shingle supply through coastal processes. This is usually in the form of longshore drift, but 'swash-aligned' beaches have few, if any, inputs due to the direction of the waves. Sediment size ranges from 2-200mm diameter and can only be moved by waves, with storm events causing material to be shifted above the reach of normal waves. The primary source of the sediment is from glacial deposits pushed landward by rapidly rising seas after the last ice age. These are finite, and the material is transported by tidal currents. Long-term coastal evolution continues to occur as shorelines adjust after the last glaciation. Other sediment sources are from cliff erosion, with longshore drift taking sediment into beaches, bays, spits and nesses.

It is estimated that one third of the British coastline is fringed by shingle beaches (May and Hansom 2003), but very little of this can support vegetation growth other than a few annual plant species. Perennial vegetation can only grow once coastal processes have built up storm beaches above the high tide line. There are only 5,810 ha of vegetated shingle in the UK (Jones *et al* 2011), with around 40% occurring at just one site, Dungeness, in Kent (JNCC 2007).

Locations where shingle has been laid down will require a continuing supply of new material, or they will gradually reduce in extent. Although shingle systems are present around the UK coastline, it is a globally restricted habitat type, elsewhere mainly found in Japan and New Zealand. Some shingle bars formed in early post-glacial times are now partly covered by sand dunes as a result of rising sea levels leading to increased deposition of sand.

Shingle structures in their natural form are of significant geomorphological interest and some sites are notified for their active coastal geomorphology. Gravel barriers are distinctive coastal forms in which morphological inheritance and sediment sorting provide major controls on how they evolve. Coastal landforms can switch from being drift-aligned to swash-aligned in response to changes in sediment supply and volume. A drift-aligned shore needs constant supplies of sediment from longshore drift, whereas a swash-aligned shore re-works existing sediment but moves landward.

The primary beach ridges in particular contribute to flood risk management, especially in the south of England. The ability of a gravel ridge to slow wave run-up and absorb wave energy, as well as allowing water to percolate into it, provides the main flood risk management benefit rather than crest height. In some locations they have been managed to raise the crest height, but such practices are being reviewed in many cases. It is vital that the geomorphic controls and limitations on any system are fully understood, especially where gravel structures are present in a mosaic with other coastal habitats. Information about managing beaches in the context of reducing flood risk has been collated in the 2010 version of the Beach Management Manual (Rogers *et al* 2010).

In the UK, the largest areas are in the northwest, south and southeast. The shingle in the northwest tends to be associated with fringing beaches and spits and in the south east major structures such as Dungeness in Kent.

Ecology

The habitat type consists of vegetated and un-vegetated surfaces, both influenced by the overall morphology of the system. Typically, it is a combination of level or gently-sloping upper beaches exposed to salt-spray and periodic disturbance by storms and the highest tides, backed by a more stable landward area formed from previous beach ridges. Vegetation colonisation is influenced by the sorting of large and smaller particles and the ability of seed to establish in what is a very harsh environment. The extent of the landward area can vary from a few ridges on spit systems to several hundred on the larger formations, representing thousands of years of development.

Vegetation communities are described in Rodwell (2000) and in more detail in Sneddon and Randall (1994).

Vegetation communities vary with the stability of the shingle, the amount of fine material amongst the shingle, and the hydrological regime. The seaward areas are only sparsely and seasonally vegetated by pioneer species, tolerant of sea spray and annual change. Plants have seeds that are distributed by waves and get nutrients from decaying seaweed and other debris. In the landward areas of the shingle, where conditions are more stable, grassland, heath and scrub communities can develop. Shingle supports a number of species largely confined to this habitat, as well as those also associated with sand dune and saltmarshes (Murdock *et al* 2010).

Species typical of the seaward edge are those which can cope with exposure to salt spray and some degree of burial by sediment, or are annuals colonising each year after winter storms. Perennials include sea kale *Crambe maritima*, sea pea *Lathyrus japonicus*, sea beet *Beta vulgaris*, and sea campion *Silene uniflora*. Annuals include Babington's orache *Atriplex glabriuscula*. The annual vegetation needs the right combination of seed supply, seasonal stability and nutrients to establish. Seed production is essential to maintain its presence, and most species have seeds that can float to enable transport by wave action. Seeds cannot establish if they are buried too deeply. As a result, the location of the vegetation may vary from one year to the next. The plant species that are adapted to the conditions are limited, and there are geographical variations from north to south (JNCC 2007). This community remains highly vulnerable to human disturbance, including trampling from recreational activities (JNCC, 2013).

Away from the tideline, where conditions are more stable, mixed plant communities develop, and over time can form grassland, heath, moss and lichen communities, and even scrub. Some of these communities appear to be specific to shingle, and some are only known from Dungeness. On the parallel ridges of cuspate forelands, patterned vegetation develops, due to the differing particle size and hydrology. A few shingle sites contain natural hollows which develop wetland communities. Where gravel extraction has taken place, some similar wetland vegetation can colonise at the fringes of restored gravel pits. Saline lagoons are often associated with shingle systems, as the sediment allows exchange of sea water,

Shingle structures may support breeding birds, including gulls, waders and terns. Diverse invertebrate communities are found on coastal shingle, with some species restricted to shingle habitats. There are specialised invertebrates found on both vegetated and bare shingle, with some living deep in the matrix where humidity and temperature are suitable for survival.

Potential climate change impacts

Cause	Consequence	Potential impacts
Sea Level Rise	Altered coastal dynamics in long term	■ Changes to the amount of sediment being supplied naturally from offshore sources and removed from shingle beaches and systems, such that loss may exceed supply. This will also be affected by adjacent hard defences that restrict sediment supply from erosion and longshore drift of sediment into shingle systems. This can lead to sediment starvation and breakdown of systems, plus demands for more artificial recycling and hard defences.
Increased storminess and more frequent extreme events	Altered coastal dynamics over short time periods	■ The level of impact will depend on the current degree of natural function. Systems with intervention, e.g. in form of re-shaping the beach crest with bulldozers, will experience the most extreme impact as the natural evolution has been prevented. More natural systems are more resilient, and beach ridges can breach, roll back and develop new morphology. ■ Storms can help create new beach ridges when pulses of sediment are pushed above normal high tide limits. If there is enough sediment then this helps sustain systems and adds new areas for vegetation to colonise.
Increased wave heights	Increased erosion	■ Increased wave action can lead to beach lowering and steepening of the foreshore. ■ Changes in shoreline position and shingle system area is likely to affect mobility, and groundwater levels.
	Human intervention e.g. hard sea defences	■ Hard sea defences can alter coastal dynamics, with loss of sediment exchange and a lowering of beach levels, leading to increased wave energy and more erosion.
Higher annual average temperatures	Longer growing season	■ This may favour some species over others. Species needing cold stratification could decline. Invasive species may become more vigorous and able to spread faster than control measures. Hot dry summers may affect growth patterns of annual species, but this is not well-researched on this habitat.
Drier summers	Drought	■ Periods of drought could result in lower water tables and lead to saline intrusion.
	Warmer weather	■ A rise in visitor numbers could increase the potential risk of trampling and impacts on vegetation and breeding birds.

Adaptation responses

Coastal shingle environments generally require limited management for nature conservation, particularly near the sea. Adaptation should focus on measures that work with the ongoing changes in morphology of the coastal system. Management plans should be developed with understanding of the likely changes. Information about this may be available through a range of sources, including Shoreline Management Plans (SMP). Habitats behind shingle systems may be affected by future change, and plans should consider any habitat replacement needed in advance.

Where there are no existing erosion control measures these should not be introduced. Neither is it desirable for shingle beaches to be re-worked artificially after storm events. The SMP policy will influence decisions on the maintenance or removal of any existing flood risk management measures, but generally conservation sites should work towards a non-intervention policy. Avoid installing any infrastructure or ensure it can be easily adapted and its condition regularly reviewed. An understanding of the geological and geomorphological processes of the site in a wider context will be beneficial, as coastlines rarely function within individual ownership units. Generic guidance for considering adaptation of flood risk management infrastructure is provided in the LWEC report card (Sayers and Dawson 2014)

Visitor pressure should be managed to ensure existing sensitive areas of habitat are avoided, in order to maintain quality and promote natural recolonisation of vegetation.

Some of the potential adaptation options for this habitat are outlined below.

- Restore or maintain habitat in favourable condition and ensure that non-climatic pressures on vegetated shingle areas (such as gravel extraction, coastal defence works, building construction, military use, agriculture, forestry and recreational pressures) are reduced.
- Develop management plans that take account of predicted changes within and beyond the site.
- Consider how activities on adjacent holdings may influence the capacity of the site to adapt, and ensure impacts are minimised. Use an understanding of shingle coastal processes to predict likely changes at a site level and adjust management accordingly. Avoid trying to maintain the current orientation of the beach ridge by artificial methods.
- Assess whether there is adequate space for shingle systems to migrate, and ensure sediment supplies into the site are not compromised.
- Adjust designated site boundaries and interest features as coasts evolve, with the aim of enlarging functional units.
- Together with owners, plan for the relocation of buildings or infrastructure within the site and behind or on shingle systems (as has been done for parts of the MOD ranges at Dungeness).
- Promote better management of shingle systems for flood risk management: avoid frequent artificial re-profiling and move towards wider beaches. This may need careful consideration where assets are present, but there are some good examples of adaptive management, including those contained in the **IPENS Coastal Management Theme Plan** (Natural England 2015).
- Plan for managing a potential increase in visitors, within a wider access strategy, for example by introducing zoning, better information, and wardening of rare species and breeding birds.
- Monitor the spread of potentially invasive species and plan for introducing control measures where necessary.

Relevant Countryside Stewardship options

CT1 Management of coastal sand dunes and vegetated shingle.

This option aims to ensure the appropriate management of existing coastal sand dune and vegetated shingle sites, whether in good condition or needing restoration.

CT2 Creation of coastal sand dunes and vegetated shingle on arable land and improved grassland.

This option aims to create sand dunes and coastal vegetated shingle on arable land or improved grassland locations which were formerly part of sand dune or shingle systems, or are adjacent to such active systems.

Yellow Horned-poppy *Glaucium flavum* on a shingle bank near Cley, North Norfolk. © Natural England/Julian Dowse

Further information and advice

A Guide to the Management and Restoration of Coastal Vegetated Shingle (Natural England, 2003).

The **Report Cards** published by the Marine Climate Change Impacts Partnership provide an overview of the impacts of climate change on marine and coastal environments. More detail is provided in a series of briefing papers, including **Impacts of Climate Change on Coastal Habitats** (Laurence Jones *et al* 2013).

Relevant case study examples

Natural England, **Coastal evolution in Suffolk: an evaluation of geomorphological and habitat change** ENRR647 (2006).

Key evidence documents

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